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A REPORT GUIDE TO ULTRASONIC ATTENUATION LITERATURE

MONOGRAPH SERIES

by

ERNEST H. RODGERS

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MATERIALS TECHNOLOGY DIVISION

U. S. ARMY MATERIALS RESEARCH AGENCY

WATERTOWN, MASSACHUSETTS 02172

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Materials Technology Division

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PREFACE

This journal was prepared by the U. S. Army Materials Research Agency (AMRA) and all information contained herein was taken from the Nondestructive Testing Information Retrieval System.* All items included cover some aspect of Ultrasonic Attenuation even though the majority include numerous other descriptors. Each item is covered by as many descriptors as was deemed necessary for complete coverage of that item.

The intent of this journal is to assist research investigators and industrial inspection personnel by providing a ready reference and access to the extensive and widely scattered literature on the subject matter.

The information contained in the Nondestructive Testing Information Retrieval System has been obtained from numerous sources such as the Defense Documentation Center; NASA; Engineering Index; foreign translations; numerous books; technical journals, etc. Many of the items listed were taken directly from complete reports currently on file at AMRA, while others may have been taken directly from abstract cards on the subject matter supplied by DDC, World Information Files, etc.

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Henry Brutcher Technical Translations,** Altadena, California

Materials Evaluation (formerly Journal of Nondestructive Testing), Evanston, Illinois

Ultrasonics, Illife Publications Ltd., London, England

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*JOHNSON, P. W., and MERHIB, C. P. The Nondestructive Testing Information System. U. S. Army Materials Research Agency Monograph Series, AMRA MS 64-02, March 1964.

**In the abstracts, Henry Brutcher Technical Translations are identified by the initials HB.

CONTENTS

INTRODUCTION

Where available, each item in this journal consists of the following information: (1) item report, or article title, (2) author or authors, (3) source or facility, (4) report number or identification, (5) date, and (6) abstract.

Word descriptors pertinent to each item are listed in alphabetical order and are cross-referenced by the AMRA identification number. Also provided is an author index or, if no author is available, then the issuing organization is listed.

OBJECTIVE

The main objective of this compilation is to provide a simple and fast access to information on the subject of Ultrasonic Attenuation, and also to provide sufficient information in the form of abstracts and word descriptors to make the listing useful.

SCOPE

This guide consists of a bibliography of items currently in the AMRA Nondestructive Testing Information Retrieval System covering the subject of Ultrasonic Attenuation. It is realized that there are many items, both foreign and domestic, that may not be included; however, it is believed that sufficient information is available to make this guide extremely useful and time saving to those interested.

If sufficient interest is noted from comments to this guide, additional guides will be prepared on other methods in the field of nondestructive testing.

Supplements to Ultrasonic Attenuation literature will be prepared as the system grows and sufficient data is available.

SOURCES

The information contained herein and in the AMRA Nondestructive Testing Information Retrieval System has been gathered from many sources such as the Defense Documentation Center, World Information Files, Engineering Index, foreign translations, numerous books, technical journals, and Department of Defense installation reports.

USAGE

All word descriptors included in this guide are listed in alphabetical order and are cross-referenced to the AMRA report identification number. Also listed is an author index, or, if no author name is available, then the issuing organization is listed. Users have only to refer to those descriptors that they are concerned with at the time and read only those abstracts which the descriptors cross-reference.

The abstracts normally refer the reader to the source where the complete report may be obtained if the reviewer desires to do so.

ABSTRACTS

4   DETERMINATION OF THE CAUSE OF FAILURE AND NONDESTRUCTIVE TECHNIQUES
FOR SEGREGATING REJECTABLE 20MM M39 MACHINE GUN BARRELS
E. H. Rodgers, J. M. Ingraham, E. L. Reed and J. W. Orner
U. S. Army Materials Research Agency, Watertown, Mass.
WAL TR 761.5/1, September 1959, 15 p.

Evaluation of the mechanical and metallurgical properties of ruptured
20MM M39 machine gun barrels confirmed the brittle nature of the
fractures and the inadequacy of the applicable machine gun barrel
specification for the procurement of clean, tough steel. Nondestruc-
tive tests were developed utilizing the magnetic properties and the
ultrasonic attenuation characteristics of the material whereby
barrels having undesirable microstructures (and therefore low impact
values) could be easily detected.

8   SPECTRUM AND CONTOUR ANALYSIS OF ULTRASONIC PULSES FOR IMPROVED
NONDESTRUCTIVE TESTING
O. R. Gericke
U. S. Army Materials Research Agency, Watertown, Mass.
WAL TR 830.5/1, December 1960, 19 p.

A novel technique for obtaining the ultrasonic attenuation/frequency
relationship in a single operation is suggested and investigated.
This new method employs ultrasonic pulses which contain energy over
a wide band of frequencies, and uses a spectrum analyzer to detect
the frequency dependence of ultrasonic attenuation.

13 ULTRASONIC ATTENUATION IN SAE 3140 AND 4150 STEEL
E. P. Papadakis
U. S. Army Materials Research Agency, Watertown, Mass.
WAL TR 143/31, April 1959, 23 p.

The attenuation of longitudinal ultrasonic waves is studied by the
pulse technique in blocks of SAE 3140 and 4150 steel to determine
the loss mechanism and to find possible methods for precision test-
ing the microstructure of materials. It is found that scattering
by the grains in the polycrystalline steel is responsible for the
attenuation in tempered steel. The critical quantities are the grain
diameter and the average squared fractional variation in the elastic
modulus of a single grain. The value of the average squared frac-
tional variation in the elastic modulus in bainite seems to be
larger than in martensite or ferrite. Methods of materials testing
to investigate grain size and grain quality are outlined.

14 DETECTION BY NONDESTRUCTIVE TESTS OF OVERHEATING IN 2014-T6
    ALUMINUM ALLOY
    P. C. McEleney and E. L. Reed   AD 238270
    U. S. Army Materials Research Agency, Watertown, Mass.
    WAL TR 140/27, May 1960, 45 p.

    Ultrasonic attenuation tests have proved to be successful in the
    detection of "overheating" or "burning" in 2014-T6 aluminum alloy.
    Heretofore overheating was detected only by metallographic examination.
    Correlation between ultrasonic attenuation tests and metallographic
    studies of a series of overheated and non-overheated 2014-T6 aluminum
    alloy samples has been successfully accomplished. Liquid penetrant,
    radiographic and electromagnetic tests can also be applied in certain
    instances to detect this condition.

15 ULTRASONIC DOUBLE REFRACTION IN 4150 STEEL
    P. F. Sullivan
    U. S. Army Materials Research Agency, Watertown, Mass.
    WAL TR 143/38, June 1961, 9 p.

    In this work the double refraction observed while measuring the
    attenuation of ultrasonic transverse waves in heat-treated 4150
    steel was investigated. Although the data are not complete, it is
    suggested this double-refraction phenomena can be utilized to detect
    the amount of preferred orientation of the crystallites in rolled
    steel when this orientation is small. Calculated values of frac-
    tional velocity differences are given.

16 ULTRASONIC ATTENUATION AND PHYSICAL PROPERTIES OF METALS
    J. W. Orner   AD 609897
    U. S. Army Materials Research Agency, Watertown, Mass.
    Watertown Arsenal Labs MS-20, November 1960, 11 p. w/illus.

    The relation of ultrasonic attenuation in a solid to the large number
    of intrinsic variables involved is qualitatively discussed. Some of
    the variables are: Frequency, strain, temperature, strain cycling,
    fatigue, grain size and orientation, and radiation damage. Prac-
    tical solutions to the problem of heat treatment of gun barrels and
    aluminum are described.

86 MANUAL FOR ULTRASONIC ATTENUATION UNIT
    WAL M-1, July 1961, 31 p. w/illus., U. S. Army Materials Research
    Agency, Watertown, Mass.

    Information on the application of ultrasonic attenuation and velocity
    in solids, is presented. Such topics are considered as construction,
    operation and calibration of equipment, correction of data obtained
    by means of the equipment, and such general topics as preparation
    of samples, transducers and coupling.

87 DETERMINATION OF FLAW GEOMETRY BY ULTRASONIC PULSE CONTOUR AND
    SPECTRUM ANALYSIS
    J. J. Maguire
    U. S. Army Materials Research Agency, Watertown, Mass.
    WAL TR 830.5/2, July 1961, 14 p.

    This report describes the application of ultrasonic pulses of almost
    rectangular envelope to pulse-echo testing, resulting in the simul-
    taneous transmission of a wide band of ultrasonic frequencies. In
    comparison to the essentially monochromatic ultrasound used in con-
    ventional test systems, this method permits the derivation of addi-
    tional information from the test, obtained in the form of the spectral
    energy distribution after reflection from the defect. Besides
    determining the location of a flaw, it is now possible to gather data
    representing the flaw geometry.

92 ULTRASONIC POLE PATTERNS
    E. P. Papadakis
    U. S. Army Materials Research Agency, Watertown, Mass.
    WAL TN 143/39, July 1961, 7 p.

    The theory of ultrasonic wave propagation in polycrystalline metal
    is discussed and the effect of preferential orientation of crystal-
    lites on fractional velocity changes is indicated. The use of
    ultrasonic double refractional data for determining extent of pref-
    erential orientation is suggested.

93 THE GRAIN SIZE DISTRIBUTION IN METALS AND ITS INFLUENCE ON ULTRA-
SONIC ATTENUATION MEASUREMENTS
E. P. Papadakis
U. S. Army Materials Research Agency, Watertown, Mass.
WAL TR 830.4/1, February 1961, 18 p.

A transformation (derived by relating the number of spheres of a
certain radius per unit volume to the number of circles smaller than
a certain radius per unit area appearing on a plane cutting through
the volume) was applied to several hypothetical grain size distri-
butions for polycrystalline metals to find the resulting hypothetical
area distribution of grain images on photomicrographs. Comparison
of the hypothetical to the experimentally found area distribution
gave certain conditions that the true volume distribution of grains
must meet. A correlation was computed for the attenuation formulas
for Rayleigh scattering of ultrasonic waves in polycrystalline metals
by taking averages over certain functions which were judged plausible
for the volume distribution of grains.

95 THE INTERACTION OF ELECTRONS WITH ELASTIC WAVES IN SOLIDS WITH
RESPECT TO ULTRASONIC ATTENUATION
E. P. Papadakis
U. S. Army Materials Research Agency, Watertown, Mass.
WAL TR 143/32, May 1960, 30 p.

Theoretical and experimental work by many researchers shows that the
attenuation of ultrasonic elastic waves in metals at liquid helium
temperatures is dependent upon the momentum transfer between the
electrons and the lattice, the population of electrons in the normal
and superconducting states, and the orientation of the elastic dis-
placement with respect to an applied magnetic field. The work is
summarized and the results presented in equations and graphs.

122 USE OF ULSTRASOUND FOR STUDY OF THE STRUCTURE OF STEELS
L. G. Merkulov
HB 4057, Zhurnal Tekhnicheskoi Fiziki, Vol. 27, No. 6, 1957,
p. 1387-1391

Application of ultrasonics (frequency to 60 mc) attenuation of
longitudinal waves as a measure of grain size and structural state
is reported. Attenuation by scattering and damping is considered;
the former is related to grain size determination and the latter to
the determination of structural state produced by heat treatment.
Medium carbon structural steel, 1.2 carbon tool steel and chrome-
nickel alloy steel were investigated.

147   ULTRASONICS IN THE STUDY OF HIGH TEMPERATURE BEHAVIOR OF MATERIALS
      R. Truell
      Proc. of Bureau of Naval Weapons, Missiles, and Rockets Symposium,
      Concord, California, 1961, p. 264-265

      Ultrasonic measurements are closely related to the compressibility,
      strain energy, and the elastic moduli. Measurements can show changes
      in these fundamental properties of material with temperature and
      transitions, and thus give information about bonding forces, cohesive
      energies, thermal expansion, specific heat, density, and details of
      the structure and behavior of dislocations.

162   QUALITY INSPECTION OF MATERIALS BY ULTRASONIC METHODS IN JAPAN
      T. Hirone, Tokyo University
      Proc. of the Third International Conf. on NDT
      Tokyo, 1960, p. 317-324, Pan-Pacific Press, Toyko, 1961

      This article describes investigations conducted in Japan on the
      method of measuring ultrasonic attenuation and its relationship be-
      tween attenuation and internal stress or creep deformation. It
      points out that ultrasonic velocity and attenuation coefficients
      in metals are influenced remarkably by the heat treatment or by
      their macro or microstructures. Ultrasonic attenuation character-
      istics are greatly influenced by the quenching and annealing of
      steel. A bibliography of papers covering this type of work con-
      ducted in Japan is included.

167   THE USE OF ULTRASONIC METHODS FOR THE EXAMINATION OF FATIGUE EFFECTS
      IN METALS DURING THE EARLY STAGES OF STRESS CYCLING
      R. Truell, et al
      Metals Research Laboratory, Brown University, Providence, R. I.
      WADD TR 60-920, December 1960, 28 p.

      Ultrasonic methods for studying defect formation and its consequences
      in connection with stress cycling and fatigue of aluminum are dis-
      cussed. The measurement of changes of ultrasonic attenuation and
      velocity during stress cycling are shown together with the accom-
      panying changes in the metallographic character of the surface sample
      as determined by acetate replicas and optical methods as well as
      oxide replicas and electron micrographs. The creation and improvement
      for the automatic recording of attenuation and velocity changes has
      been a major part of the effort thus far, and a discussion of this
      equipment appears here.

181 THE STUDY CONCERNING THE RELATION BETWEEN THE TRANSMISSION SPEED OR
THE ATTENUATION DEGREE OF ULTRASONIC AND THE DEGREE OF GRAPHITIZATION
K. Kanazawa and Y. Ueda
Proc. of the Third International Conf. on NDT
Tokyo, 1960, p. 636-641, Pan-Pacific Press, Tokyo, 1961

This article describes studies conducted with relation to the trans-
mission speed or the attenuation degree of ultrasonics and degree of
graphitization about the specimens which were graphitized by anneal-
ing at temperatures between 650°-670°C after quenching or welding.
Ultrasonic attenuation comparators and synchroscopes were utilized
in the studies. The authors state that the transmission speeds of
ultrasonics decreased three to five percent, and the attenuation
degree of ultrasonics rapidly increased to four or five times when
the degree of graphitization in the specimen matrix grew severe as
compared to slight graphitization or none at all.

182 ULTRASONIC FLAW INSPECTION OF METALS AT HIGH TEMPERATURES
T. Hirone and K. Kamigaki, Tokyo University
Proc. of the Third International Conf. on NDT
Tokyo, 1960, p. 631-635, Pan-Pacific Press, Tokyo, 1961

An extensive investigation of the use of ultrasonic flaw inspection
methods at high temperature ranges is discussed in this article.
These investigations cover ultrasonic attenuation and velocity
measurements, flaw detection at both high and room temperatures and
the results compared with X-ray techniques. Confirmation of the
results show that the distribution of flaws detected by ultrasonic
methods at high temperatures coincide with those taken at room
temperature and correlate well with radiography.

189 NONDESTRUCTIVE TESTING OF REACTOR FUEL ELEMENTS AT HANFORD
R. S. Paul, General Electric Co., Hanford Works
Proc. of the Third International Conf. on NDT
Tokyo, 1960, p. 423-428, Pan-Pacific Press, Tokyo, 1961

This paper describes the continuing research program underway at
Hanford in an attempt to find new test methods, to improve the sensi-
tivity and reliability of present tests, and to automate for high
volume testing. Ultrasonic attenuation methods used to test for
proper grain size is explained as well as sonic resonance vibration
test for grain orientation investigations. Both ultrasonic and eddy
current flaw detection techniques are discussed. Advanced research
currently in progress in the fields of broadband or multi frequency
eddy current testing as well as new ideas in ultrasonic testing and
infrared methods of measuring heat transfer characteristics is out-
lined.

193 ATTENUATION AND VELOCITY MEASUREMENTS IN 1013 STEEL AS A FUNCTION
OF DEFORMATION AND HEAT TREATMENT
A. Hikata and R. Truell
Brown University, Providence, R. I.
WAL 143/20-48, January 1958, 11 p. w/graphs

Ultrasonic attenuation and velocity measurements were made in 1013
steel while the steel was being deformed. A rather strange atten-
uation-strain behavior results. This behavior apparently is not
caused by dislocation damping changes or scattering but preliminary
results support the contention that this is at least in part a
magnetic phenomenon. It is also shown that the attenuation-strain
behavior is sensitive to the heat treatment to which the sample has
been subjected.

221 INVESTIGATION OF RESIDUAL STRESS IN FERROMAGNETICS USING ULTRASONICS
W. J. Bratina and D. Mills
SNT Journal, March-April 1960, p. 110-113

Ultrasonic attenuation characteristics are used to study the residual
stresses in low carbon steels. The presence of a residual stress is
shown to be indicated by a characteristic maximum in the ultrasonic
attenuation plotted versus applied stress on magnetic field. Mag-
nitude is related to the position of the maximums. Microstresses
are mainly considered and they appear readily detectable. Further
development of this method could lead to a practical means for
nondestructive determination of stresses in metals.

238 EARLY DETECTION OF FATIGUE IN METAL ALLOYS BY ULTRASONICS
K. Sittel
SNT Journal, May-June 1959, p. 165-171

Solid metals readily transmit acoustic waves, but the wave energy
is attenuated to some extent by various causes such as heat conduc-
tion, motion of dislocations, motion of grain boundaries, movements
of atoms, and scattering. These are explained as are the means for
separating attenuation caused by other effects. It is believed that
the growth and movement of dislocations is actually the predominant
process occurring in the early stages of fatigue damage. Hence,
the damage may be found before the structural part becomes measurably
weakened. Present acoustical methods are described and their appli-
cation to fatigue studies are given. Effects which occur in the
fatigue life of a specimen are described. The circumstances under
which these phenomena may be observed ultrasonically are pointed
out. The choice of a test sample for fundamental study is dis-
cussed, and some suggestions are made for routine testing.

292 ULTRASONIC ATTENUATION AND VELOCITY IN SAE 4150 STEEL
E. P. Papadakis et al
U. S. Army Materials Research Agency, Watertown, Mass.
WAL TR 143/37, December 1961, 88 p. w/graphs

Ultrasonic attenuation and velocity measurements have been made on
SAE 4150 steel in the hot-rolled, austenitized-and-quenched, and
tempered conditions to study temper embrittlement. It was found that
the ultrasonic measurements did not show any correlation with the
hardness or the notched-bar breaking energy of the steel. The atten-
uation from both elastic hysteresis and Rayleigh scattering decreased
on quenching and also on tempering. The reduction of residual
stresses lowered the elastic hysteresis. The decrease in Rayleigh
scattering was caused partially on quenching and entirely on tem-
pering by reductions in the elastic anisotrophy of the contents of
the prior austenite grain volume. Ultrasonic double refraction was
observed during transverse wave measurements on the tempered speci-
mens.

385 AN ULTRASONIC ATTENUATION MEASURING EQUIPMENT
G. A. Darcy, Jr. and W. J. Curry
U. S. Army Materials Research Agency, Watertown, Mass.
WAL 143/25, 1 November 1952

An ultrasonic attenuation measuring equipment for use on steel has
been designed and constructed. This equipment is being employed to
investigate the possibility of supplanting certain destructive tests
with nondestructive ultrasonic tests. The device has a frequency
coverage of 5 to 30 megacycles and an input sensitivity of 2.5
microvolts.

484 ATTENUATION OF 5 MC SOUND IN ALUMINUM AT LOW TEMPERATURES
T. S. Hutchison and A. J. Filmer
Royal Military College, Kingston, Canada
Reprint, Canadian Journal of Physics, 1956

It has been found that the attenuation of sound reaches a maximum
when using a frequency of 5 megacycles at 155°K in aluminum. Plas-
tic deformation greatly increases the maximum. The maximum differ-
ence in the velocity of sound for cold-worked and annealed aluminum
appears at 155°K which indicates dislocation mechanism.

506 ATTENUATION OF ULTRASOUND IN TUNGSTEN CARBIDE POWDER MIXTURES AT
MEGACYCLE FREQUENCIES
R. L. Roderick and R. Truell
Brown University, Providence, R. I.
WA Contract DA-19-020 ORD 48, 1951

The attenuation of longitudinal ultrasound in the frequency range
from 10 to 30 mc was measured in two tungsten carbide powder mixtures
of different average grain sizes using the pulse technique and a
water buffer. The larger grain size specimen had larger attenuation
coefficients. Both Rayleigh scattering and true absorption appear
to be inadequate to explain the attenuation observed. A method is
suggested for detecting "flaws" which are not pronounced enough to
actually reflect the sound pulses. A more extensive sampling is
necessary before a good empirical law can be formulated.

551 ULTRASONICS AND THE PHYSICS OF SOLIDS
R. Truell
Brown University, Providence, R. I.

A survey will be given of some of the uses of ultrasonic attenuation
and velocity measurements in the study of the properties of solid
materials. An outline will be given of the relative importance of
scattering and dislocation damping in various applications to the
study of the "quality" of materials. Deformation, fatigue, and
radiation effects will be discussed to the extent that time permits.

554 PRELIMINARY ATTENUATION DATA WITH STEEL SAMPLES OF DIFFERENT HARDNESS
R. L. Roderick and R. Truell
Brown University, Providence, R. I., Contract DA-19-020-ORD-13, 1950
WAL 143-14-7

This article cites preliminary Attenuation Data with Steel Samples
(37MM A. P. Shot) of different Hardness. It has been found that
the boundary measurements do have an important effect on the meas-
urements independent of the material. Further work is necessary.

556 ULTRASONIC ATTENUATION IN THE STUDY OF ELASTIC AND PLASTIC DEFOR-
MATION BEHAVIOR ESPECIALLY IN ALUMINUM
A. Hikata, R. Truell, A. Granato, B. Chick and K. Lucke
Brown University, Providence, R. I., Contract DA-19-020-ORD-1579,1955
WAL 143/14-45

Interesting effects have been observed in the course of comparing
measurements of ultrasonic attenuation at megacycle frequencies as
a function of strain with load-strain measurements made on the same
tensile test specimen at the same time The results show clearly
the sensitivity of ultrasonic attenuation to the fine details of the
mechanisms involved in elastic and plastic deformation.

557 ULTRASONIC ATTENUATION IN CRYSTALS DUE TO THE THERMOELASTIC EFFECT
K. Lucke
Brown University, Providence, R. I., Contract DA-19-020-ORD-1579,1956
WAL 143/14-46

The thermoelastic attenuation for sound waves has been computed for
single crystals and polycrystalline materials under application of
the high frequency approximation of sound propagation. For single
crystals the attenuation in the main propagation directions have
been computed explicitly for cubic and hexagonal crystals taking into
account the anistrophy of the elastic properties and thermal ex-
pansion.

558 MULTIPLE SCATTERING OF WAVES
P. C. Waterman and R. Truell
Brown University, Providence, R. I., Contract Nos. DA-19-020-505-
ORD-3882 and 3650, 1957
WAL 143/14-49

Governing equations are obtained for the problem of multiple scat-
tering of waves in a homogeneous isotropic medium containing a
statistical array of scattering regions. The equations are appli-
cable to sound waves in solids, liquids and gases, electromagnetic
waves, and stationary quantum-mechanical problems. From these
equations the macroscopic properties of the scattering medium may
be obtained in terms of the scattering properties of a single scat-
terer. Questions of energy and measurement are discussed, and
several examples are considered. An extension of the theory to the
elastic problem with mode conversion is included.

559 THE DETECTION OF INTERMEDIATE AND SMALL FLAWS IN SOLID MATERIALS
D. H. Evans and R. Truell
Brown University, Providence, R. I., Contract Nos. DA-19-020-ORD-1579, 1953
WAL 143/14-42

Using ultrasonic attenuation methods in solid materials it has been found that flaws which cannot be detected by conventional echo methods are nevertheless detectable by observation of certain behavior of the pulse attenuation pattern. The deviation of the pulse amplitude decay from exponential form is, under proper circunstances, evidence of intermediate or small flaws.

560 ULTRASONIC ATTENUATION OF A TEMPER EMBRITTLED STEEL
D. H. Evans and R. Truell
Brown University, Providence, R. I., Contract No. DA-19-020-ORD-817, 1953
WAL 143/14-33

Temper brittlement in SAE 4150 steel has been partially investigated by ultrasonic attenuation techniques. It has been found that the attenuation is related to the breaking energy, as given by the Charpy impact test, and to hardness. The relationship found appears to be complex in nature; the attenuation-hardness curves show sharp maxima for certain values of the hardness and of the breaking energy if the sample is tough and for other values of hardness and breaking energy if the sample is brittle.

561 DIFFRACTION EFFECTS IN THE ULTRASONIC FIELD OF A PISTON SOURCE AND THEIR IMPORTANCE IN THE ACCURATE MEASUREMENT OF ATTENUATION
H. Seki, A. Granato and R. Truell
Brown University, Providence, R. I., Contract No. DA-19-020-ORD-1579, 1954
WAL 143/14-44

A study is made of the ultrasonic field produced by a circular quartz crystal transducer and the integrated response of a quartz crystal receiver with the same dimensions as the transducer. The transducer and receiver are taken to be coaxial, and it is assumed that the transducer behaves as a piston source while the integrated response is proportional to the average pressure over the receiving area. Computations are made for cases of interest in the megacycle frequency range (Ka = 50 to 1000). The results contain features of use in identifying and correcting for diffraction errors. These features which apparently have been missed in previous investigations are compared with available experimental data. Finally, correction formulas to account for diffraction effects in the accurate measurement of attenuation are discussed.

562 NEUTRON IRRADIATION EFFECTS IN BOROSILICATE GLASS AND THEIR
DETECTION BY ULTRASONIC AND BIREFRINGENCE MEASUREMENTS
R. Truell, J. de Klerk and C. Mylonas
Brown University, Providence, R. I., Contract No. AF 33 (616) -
3019, 1957

This report summarizes the work done in studying the effect of the
reactions of slow neutrons with boron in glass. The resultant damage
or radiation effects were detected and examined by two methods: (1)
By photoelastic study of the stress pattern resulting from radiation
induced strains in the glass. The ultrasonic method showed the ex-
pected attenuation increase with irradiation but also an unexpected
reversal of the velocity-frequency behavior as compared to that
observed before irradiation. The photoelastic method showed that
the strains induced by the neutron-B^{10} reactions vary with the
depth from the glass surface in direct proportion to the neutron
flux, and that they can therefore be used for direct irradiation
measurements. Accordingly this report is divided into two parts
corresponding to the two methods used to study the radiation effects.

563 THE TEMPERATURE DEPENDENCE OF THE ATTENUATION OF ULTRASOUND IN A
NICKEL SINGLE CRYSTAL
F. West
Brown University, Providence, R. I., Contract No. DA-19-020-ORD-
3650, 1957
Office of Ordnance Research

Attenuation in the Magnetically Saturated State: From the measure-
ments of the attenuation as a function of frequency it can be con-
cluded that the energy loss in the saturated state is the result of
a relaxation loss mechanism. It is found that the relaxation frequency
is not measurably temperature dependent; however, the shape of the
relaxation curve depends on the history of the specimen. The nature
of the loss mechanism is not known, but it is probably related to the
dependence of the velocity of an ultrasonic wave on the orientation
of the saturation magnetization which has been observed by other
workers.

564 FATIGUE IN 2S ALUMINUM AS OBSERVED BY ULTRASONIC METHODS
R. Truell and A. Hikata
Brown University, Providence, R. I., Contract Nos. DA-19-020-505-
ORD-3882 and 2598
WAL 143/14-47

One of the most important results of this experiment is the fact that
at the beginning of the experiment the material had a large recovery
effect, and at the end of ten million cycles there was no detectable
recovery effect. In other words initially the material was stat-
ically loaded and, while held at constant load, the attenuation would
decrease to the initial value. At the conclusion of the fatigue
cycling the attenuation did not change. Loading to the same load
used in the experiment did not increase the attenuation and while
standing at constant strain, there was no measurable decrease in
attenuation - the recovery effect was no longer present.

566 ULTRASONIC ATTENUATION IN METALS AT LOW TEMPERATURES
D. H. Filson
University of California, Los Angeles, Cal.
Tech. Rpt. No. XIII, January 1959

Whenever mechanical waves are generated in a solid, some of the
elastic energy is always converted into heat. The mechanism by
which this energy loss occurs will depend upon the characteristics
of the wave generated and upon the properties of the solid medium.
Several theories were rapidly advanced to explain the effect in the
normal conducting state. All apparently led to the same result;
that the attenuation of shear or longitudinal waves at low frequen-
cies varies directly with the square of the frequency and with the
electronic mean free path for wavelengths greater than the mean
free path. The purpose of the present study is to examine more
closely the attenuation of ultrasonic waves due to the electron
lattice interaction.

568 ULTRASONIC ATTENUATION AND VELOCITY MEASUREMENTS IN SOLIDS
R. Truell
Brown University, Providence, R. I., Final Report, Contract No.
DA-19-020-505-ORO-3882, 1959
WAL 143/14-50, Copy No. 8

This report consists of an outline which might form the basis of a
book on the subject of "Ultrasonic Attenuation and Velocity Measure-
ments in Solids." The material is written from the point of view
that megacycle ultrasonic methods constitute a tool for the study
of the physical properties of solid materials in the same way as do
x-ray, electron, optical, and neutron diffraction methods, thermal
and electrical conductivity methods, optical and mocrowave absorption
measurements and so on. The material here presented is primarily
the story of what physical properties can be studied by megacycle
ultrasonic methods together with a discussion of the details of the
methods that have been used in such investigations. As presented
here, the discussion is certainly not complete in detail and in
parts, the discussion is abstracted or outlined briefly. The main
theme or outline is however reasonably complete.

594 MICRO-CRACK DETECTION IN STEEL FORGINGS UTILIZING ULTRASONIC ATTEN-
UATION
R. L. Buckrop
Quality Assurance Office, Rock Island Arsenal, 1961

Ultrasonic pulse-echo equipment was used for separation of forgings
with various degrees of micro-crack severity by attenuation measure-
ments. The satisfactory material could easily be separated from the
unsatisfactory. It was also possible to approximate the extent of
micro-cracking in the test specimens by a percentage comparison of
their back reflections to that of a standard.

609 INFLUENCE OF GRAIN STRUCTURE ON ULTRASONIC ATTENUATION IN STEEL
E. P. Papadakis
Watertown Arsenal Laboratories, Watertown, Mass.
Journal of Applied Physics, Vol. 30, No. 9, p. 1463, September 1959

This article makes a comparison between predicted and experimental
values of longitudinal wave attenuation when using a frequency of
15 MC/sec with a mean grain size of ASTM6.

611 ULTRASONIC METHODS FOR NONDESTRUCTIVE EVALUATION OF CERAMIC COATINGS
W. E. Lawrie
Armour Research Foundation, Illinois Inst. of Technology, April
1961, 42 p.
WADD Tech. Rept. 61-91, Part I

This report describes investigations into the use of ultrasonics to
detect defects in ceramic-metal bonds and to measure the strengths
of the bonds. In the techniques investigated ultrasonic frequencies
from 30 cps to 35 mc/s have been used and in one method two frequen-
cies are used simultaneously. Low frequency energy (14 kc/s) has
been sucessfully used to detect defects by decrement measurements.
Low frequencies have also been used in further studies of the inter-
modulation method used to locate regions of bonds in which defects
are present. High frequencies, up to 35 mc/s, have been used with
a transmission method and visual images of defects are displayed
using a simple charge scanning technique. High frequency energy
has also been used in the form of surface waves. (This work is a
continuation of investigations reported in WADD TR 60-157.)

613 ULTRASONIC ATTENUATION IN CAST ALUMINUM
H. Rosenthal and H. Smolen
Frankford Arsenal
Report No. R-1500, 20 p., March 1959

Since radiography does not clearly distinguish the difference be-
tween high quality aluminum castings and the ordinarily acceptable
grade, there is a need for a nondestructive test method for this
purpose. Aluminum test plates (7% Si-0.3% Mg) were cast with a
chill on one edge and a riser at the opposite edge. It was noted
that tensile properties decreased sharply when the area near the
chill was compared with that near the riser. Although radiographic
examination was insensitive to this change, a definite increase in
ultrasonic attenuation was noted in a direction away from the chill
edge. Tests made on 5% Si samples with various gas contents con-
firmed the observation that ultrasonic attenuation is markedly
affected by the presence of gas and microshrinkage in the samples.
Techniques for making ultrasonic attenuation measurements on com-
mercial castings were not considered in this report.

617   CORRECTION FOR DIFFRACTION LOSSES IN THE ULTRASONIC FIELD OF A
      PISTON SOURCE
      E. P. Papadakis
      Watertown Arsenal Laboratories, Watertown, Mass.
      Journal of the Acoustical Society of America, 1959

      In pulse echo ultrasonic attenuation experiments, it is important
      to know the part of the measured attenuation contributed by diffrac-
      tion in the ultrasonic field. In certain cases, particularly at lower
      megacycle frequencies in highly transmitting specimens, the diffrac-
      tion loss can be much greater than the attenuation intrinsic to the
      specimen. The diffraction loss has been computed elsewhere as a
      function of the distance the ultrasonic pulse travels back and
      forth in the sample. Here an expression for the increment to the
      attenuation is derived taking into consideration at which echoes
      the decibel drop is measured.

656   INSTRUMENTATION FOR PULSED ULTRASONIC TESTING
      J. A. Bronzo
      Metals Research Laboratory, Brown University, Providence, R. I.,
      September 1950
      WAL 143/14-6

      Equipment used for ultrasonic testing and attenuation measurements
      are described and their operation explained in detail. Block dia-
      grams are supplied.

663   ULTRASONIC ATTENUATION IN MILD STEEL UNDER DEFORMATION
      R. G. Bayer
      Brown University, Providence, R. I., September 1958

      The ultrasonic attenuation as a function of strain was studied for
      mild steel under various conditions of magnetic field and tempera-
      ture. From these experiments it has been determined that the be-
      havior of the losses in mild steel as a function of strain results
      from the combination of magnetic domain mechanisms and dislocation
      mechanisms. A heuristic model using known magnetic domain losses
      and known dislocation losses is proposed to explain the observed
      dependence.

686 INVESTIGATION OF PHYSICAL PROPERTIES OF SOLIDS BY ULTRASONIC METHODS
R. Truell   AD 274827
Brown University, Providence, R. I.

This report is an outline of the work undertaken and provides a brief
summary of the results. Most of the technical material has been
reported in technical reports and articles. Certain properties
of solid materials have been studied primarily by means of high
frequency ultrasonic methods. In particular this work has been con-
cerned with (1) study of ferromagnetic behavior in nickel single
crystals at low temperatures; (2) the interaction of stress waves
and electromagnetic waves in piezoelectric semiconductors such as
cadmium sulphide, i.e., interaction of stress waves with charge
carries; (3) phase changes in quartz and cadmium sulphide; (4)
phonon-phonon interaction in insulators and semiconductors.

733 EXPERIMENTAL STUDY OF DIFFRACTION AND WAVEGUIDE EFFECTS
E. F. Carome et al, 30 November 1960   AD 248734

An experimental study has been made of the propagation of ultrasound
in liquids under both free field and guided wave conditions. Free
field measurements have been made from one to twenty megacycles in
low absorbing liquids, employing both circular and square sound
sources. These measurements indicate that the correction for dif-
fraction loss predicted by existing theories is applicable only so
long as this loss is smaller than the true absorption. Attenuation
measurements also have been made in liquids confined in various
cylindrical and rectangular metallic waveguides. For a given con-
figuration, the observed variation with path length of the atten-
uation follows closely that predicted theoretically for propagation
in a solid sample of the same dimensions. Some consideration is
given to possible sources of this effect and to its importance in
measurement of ultrasonic velocity.

771 CONCERNING THE PULSE METHOD OF MEASURING ULTRASONIC ATTENUATION IN
SOLIDS
R. L. Roderick et al
Brown University, Providence, R. I., October 1950

The general nature of the problem under consideration discussed in
this paper is that of determining experimentally the attenuation of
ultrasonic waves in solid media. In particular cylindrical samples
of tungsten carbide and chrome steel of predetermined diameter and
lengths were examined.

782 AN ULTRASONIC ATTENUATION MEASUREMENT UNIT
     B. Chick et al
     Brown University, Providence, R. I.

     The instrument described has been developed for the purpose of
     measuring ultrasonic energy losses in various materials, primarily
     solids, using the pulse echo method. A short duration pulse of
     ultrasonic energy is allowed to reflect back and forth between the
     parallel faces of the specimen until the echoes are no longer visible.
     The pulse amplitudes are presented as a function of time and echo
     number together with a calibrated experimental decay curve which can
     be fitted to the pulse echo pattern. Frequency range is from 5 mc to
     200 mc; for special units 200 mc to 500 mc.

791 ON THE MEASUREMENT OF ULTRASONIC ATTENUATION IN SOLIDS AND SOME
     RESULTS IN STEEL
     R. L. Roderick and R. Truell
     Brown University, Providence, R. I., May 1951
     WAL Report No. 143/14-14

     Measurements in the frequency range from 5 to 50 megacycles have
     been made on chrome molybdenum steel specimens, and their measure-
     ments show large differences in ultrasonic attenuation for samples
     of the same composition but with different heat treatment. The
     resulting differences are not related to the austenitic grain size
     but they do seem to be connected with anisotropy which appears in the
     photomicrographs.

799 PROPAGATION OF ULTRASOUND IN FERROMAGNETIC METALS AT LOW TEMPERATURES
     G. Simon
     The Physical Review, Vol. 128, No. 1, 1 October 1962, p. 161

     The propagation of ultrasound in ferromagnetic metals at low tem-
     peratures has been investigated utilizing the theory of cyclotron
     absorption of ultrasonic and microwaves. Data is presented on the
     force on conduction electrons in ferromagnets. Velocity and atten-
     uation formulas of elastic waves are derived. The motion of the
     magnetization creates eddy currents.

800 FEASIBILITY STUDY OF DYNAMIC PROPERTIES OF PROPELLANT GRAINS
R. P. Demski
Aerojet-General Corp., Azusa, Calif.
Contract No. DA-04-495-3380, October 1962
Report No. 2328

The feasibility of using pulsed ultrasonic waves to test whole-grain
live propellants was investigated. Seven propellant specimens,
designated "Live Propellant for Catapult XM-10," were supplied by
Picatinny Arsenal with deliberate variations imposed during fabri-
cation. A special scanning fixture was designed and built by Aerojet
to perform some of these tests. It was shown that even prolonged
exposure to ultrasonic waves did not ignite live propellant with prop-
er safety precautions. Contact ultrasonic testing using either lon-
gitudinal or shear wave techniques did not provide accurate data.
Immersion tests employing mechanized scanning equipment and recording
apparatus were able to detect variations in the cure cycle as well
as internal flaws as small as 0.03125 in. in dia. The attenuation
characteristics of each specimen were obtained by amplitude measure-
ment of the signal response received from the back surface of the
material.

810 THE USE OF SPECTRUM ANALYZER TECHNIQUES TO INVESTIGATE FACTORS
AFFECTING THE MEASUREMENT OF ULTRASONIC ATTENUATION IN SOLIDS
D. H. Breslow
Brown University, Providence, R. I.
WAL TR 143/14-38, August 1956

This report is concerned with the effects of tuning, pulse width,
and coupling on the attenuation measured by the direct-mount, pulse-
echo method. It is shown that a spectrum analyzer may be used to
determine the proper tuning, pulse width, and coupling for a specific
transducer and sample and also to select a receiver of proper band-
width for the required measurements.

1050 DETERMINATION OF THE SIZE OF DEFECTS BY THE ULTRASONIC IMPULSE ECHO
METHOD
J. Krautkramer
British Journal of Applied Physics, June 1959, p. 240-245.

Calibration and standardization of ultrasonic test equipment is
considered. Influence of curvature of test and back surfaces is
covered. A convenient and reliable reference signal can be obtained
from the first back echo. Ultrasonic attenuation of thick specimens
is also covered.

1068   ULTRASONIC MEASUREMENTS ON AN UNTREATED NaCl SINGLE CRYSTAL
        E. Papadakis
        Massachusetts Institute of Technology, August 1959

        The scope of this special problem includes the measurements able
        to be made by propagating ultrasonic pulses in the (100) direction
        in a Sodium Chloride single crystal. The velocity of longitudinal
        waves in this direction determines the elastic constant C_{11} while
        the velocity of transverse waves determines C_{44}. Measurements of
        the attenuation can give an indication of the loss mechanism oper-
        ating in the crystal and abstracting energy from the ultrasonic wave.

1070   FATIGUE AND ULTRASONIC ATTENUATION
        R. Truell and A. Hikata
        Symposium on Nondestructive Testing
        ASTM Technical Pub. 213, 1957

        Experiments conducted in this laboratory over the past several
        years have shown that appreciable changes occur in the propagation
        and recovery behavior of ultrasonic waves in materials during stress
        or fatigue cycling. Although most of the exploratory work has been
        done on three types of aluminum, the method is not restricted to
        aluminum. The following is a brief survey of the effects observed,
        and no explanation of the observed behavior is offered. Some ex-
        planation is offered in an earlier report by the authors. The
        results of the work show that in all cases studied the ultrasonic
        attenuation increases as a function of the number of cycles of
        loading and unloading. The loading in these experiments was done
        in tension and in tension and compression. The form of the atten-
        uation-cycles curve depends among other things on the magnitude of
        the load and the speed of cycling.

1071   THE EFFECT OF HYDROGEN ON ULTRASONIC ATTENUATION AND VELOCITY
        MEASUREMENTS IN TITANIUM
        C. F. Ying and R. Truell
        Brown University, Providence, R. I., OOR Contract No. D. A.-19-020-
        ORD-1512
        Acta Metallurgica, May 1954

        This report covers the investigation of titanium before and after
        heat treatment in hydrogen by ultrasonic attenuation and velocity
        measurements in the range of 10 to 50 Mc/s. Attenuation decreased
        greatly with increased hydrogen content.

1209　METHODS FOR NONDESTRUCTIVE EVALUATION OF PHYSICAL PROPERTIES IN
　　　RUBBER SOLID COMPOUNDS
　　　J. G. Martin
　　　IRE-Western Electronic Show and Convention
　　　Paper No. 37/1, 1961

　　　This paper points out that correlation and measurements effecting
　　　changes of mechanical behavior are possible, when interference
　　　effects of the transducer-specimen method are predictable. There-
　　　fore, the use of ultrasonic attenuation to detect the characteristics
　　　of heavily loaded elastmeric materials is feasible.

1295　METHOD FOR MEASURING ATTENUATION OF ULTRASONIC LONGITUDINAL WAVES
　　　IN PLASTICS AND ROCKS
　　　M. Auberger and J. S. Rinehart
　　　Journal of the Acoustical Society of America, December 1960

　　　This report covers the use of the pulse technique for measurement
　　　of attenuation of longitudinal waves in rocks and plastics. Fre-
　　　quency range data is given from 250 Kc to 1000 Kc for granite and
　　　Plexiglass.

1349　IMPLICATIONS OF ULTRASONIC ATTENUATION TO NONDESTRUCTIVE TESTING
　　　J. K. White, R. W. McClung and J. W. Allen
　　　Oak Ridge National Laboratory
　　　ORNL-2651 April 1959

　　　In order to relate ultrasonic inspection data to actual conditions
　　　inside a metal part, it is essential that the inspector have some
　　　knowledge of attenuation as it affects ultrasound. This paper
　　　briefly reviews the theory of attenuation of ultrasonic energy. It
　　　discusses the first part of a study being conducted for the purpose
　　　of understanding and evaluating the large losses encountered in
　　　cast and welded steels. The equipment required and techniques
　　　employed for measuring attenuation are described. The results of
　　　these attenuation measurements are described with special reference
　　　to weld inspection.

1393 THEORY OF ULTRASONIC ATTENUATION IN CYLINDRICAL AND RECTANGULAR
     WAVEGUIDES
     E. F. Carome and J. M. Whiting
     Journal of the Acoustical Society of America, February 1961,
     p. 187-197

     Theoretical attenuation studies in cylindrical and rectangular wave-
     guides is discussed. Both the receiver and the source were of the
     same size. Path length acoustic loss is computed for the various
     waveguide and source configurations.

1398 RAYLEIGH AND STOCHASTIC SCATTERING OF ULTRASONIC WAVES IN STEEL
     E. P. Papadakis
     Watertown Arsenal Laboratories, Watertown, Mass.
     Journal of Applied Physics, Vol. 34 No. 2, February 1963, p. 265-269

     Ultrasonic attenuation measurements in SAE 4150 steel at various
     stages of heat treat were made utilizing 5 to 100 Mc frequencies.
     Changes in grain diameter and anisotropy changes the attenuation
     which is in fairly good agreement with theories of scattering by
     grains in metals. Tempering reduces the attenuation by a factor
     of 3 without a change in grain size.

1456 ULTRASONIC ATTENUATION IN LEAD
     A. R. MacKintosh
     Cavendish Lab., University of Cambridge
     Proceedings of the Royal Society, Vol. 271, No. 1344, 1 January
     1963, p. 88-104

     Absorption studies of longitudinal waves in pure single crystals
     have been made at 1.2°K in a transverse magnetic field. Results
     are generally consistent, as suggested by Gold, with the Fermi sur-
     face of lead. Detailed studies of the magneto-acoustic oscillations
     were also conducted. Absolute magnitude of attenuation in a mag-
     netic field was also studied and results given.

1485 VISUALIZATION OF ULTRASONIC EXTINCTION NETWORK IN COARSE GRAINED
     URANIUM
     R. S. Sharpe and S. Aveyard
     Applied Materials Research, October 1962, p. 170-176

     This paper describes the use of the ultrasonic pulse technique as
     applied to detection of grain refining treatment in cast uranium
     bars. Core and rim regions were inspected at the same time. Coarse
     grained uranium produced high attenuation at 6 Mc pulses.

1492   ULTRASONIC ATTENUATION UNIT AND ITS USE IN MEASURING ATTENUATION IN
      ALKALI HALIDES
      B. Chick
      Journal of the Acoustical Society of America, Vol. 32, No. 2,
      February 1960, p. 186-193

      This paper describes an ultrasonic attenuation unit developed for
      measuring attenuation and velocity in the range of 5-200 mc/sec
      frequencies. Also reported are attenuation measurements of single
      crystals of NaCl.

1552   A RECORDING ULTRASONIC INTERFEROMETER AND ITS ALIGNMENT
      J. L. Stewart and E. S. Stewart
      Journal of the Acoustical Society of America, January 1952, p. 22-26

      This article consists of three parts, a) describing a circuit using
      r. f. amplification for converting the ultrasonic interferometer
      to a selfrecording instrument for rapid determination of coefficients
      of gases at low pressures. b) describes sources of errors, their
      detection, and correction. c) Contains data velocities, attenuation,
      and reflection in Helium.

1627   ULTRASONIC ATTENUATION AND VELOCITY IN THREE TRANSFORMATION PRODUCTS
      IN STEEL
      E. P. Papadakis
      Bell Telephone Laboratories, Allentown, Pennsylvania
      Journal of Applied Physics, Vol. 35, No. 5, May 1964

      Ultrasonic attenuation measurements were applied to three products
      of steel, namely pearlite with ferrite, barnite and martensite,
      utilizing 2-100 mc/sec with longitudinal and transverse waves.
      Attenuation was highest in pearlite, intermediate in barnite and
      lower in martensite. Attenuation and velocity tables are included.

1628   ULTRASONIC ATTENUATION IN SINGLE-CRYSTAL CADMIUM
      G. Abowitz
      Cornell University, Ithaca, New York
      Journal of Applied Physics, Vol. 34, No. 5, May 1963

      Attenuation of longitudinal and shear waves in the range of 5 to
      60 megacycles per sec. frequency range was measured in cadmium
      single crystals at 300°K. Present results indicate lack of under-
      standing of acoustic damping in cadmium and zinc.

1631 EVALUATION OF A RESIN-CERAMIC HEAT-SHIELD MATERIAL BY ULTRASONIC
      TECHNIQUES
      G. E. Lockyer
      Avco Corp., Lowell, Mass., Materials Evaluation, March 1965

      This paper discusses procedures for performing nondestructive
      evaluations on a resin-ceramic material used as a heat shield for
      missile re-entry applications. The evaluation made use of ultra-
      sonic techniques, and, in particular, velocity and attenuation
      measurements. Procedures for measuring these ultrasonic properties
      are described, and studies involving their correlation with material
      properties such as bulk density, ultimate tensile strength, and
      modulus are discussed. The correlation presented indicates the fea-
      sibility of implementing such ultrasonic measurements as an aid in
      material development programs, as well as a quality control tool for
      monitoring the production phase.

1636 ABSORPTION OF ULTRASONIC WAVES IN SOLIDS
      M. Redwood   AD 281495
      Frankford Arsenal
      Translated from Revue de Metallurgie, Vol. 56, 1959, p. 172-180

      The first part of this report discusses several factors which intro-
      duce errors into the determination of the ultrasonic attenuation of
      low loss materials. A method for evaluating the losses due to re-
      flection at the transducer specimen interface is presented and the
      interference effects caused by the simultaneous generation of sig-
      nals which have various modes of propagation or vibration are dis-
      cussed in detail. The second part of the report presents a rapid
      over-all view of the various theories used to explain the frequency
      and temperature dependence of friction damping in metals. An
      extensive bibliography is presented.

1653 FREQUENCY BANDWIDTH CONSIDERATIONS IN ULTRASONIC TESTING
      C. P. Merhib
      U. S. Army Materials Research Agency, Watertown, Mass
      WAL TR 143.7/1, January 1963

      The determination of flaw geometry and flaw orientation is a complex
      and difficult problem whose solution has been sought since the be-
      ginning of ultrasonic testing. In recent work at Watertown Arsenal
      Laboratories significant advances have been made toward solution of
      this problem, but many details have yet to be resolved. The fre-
      quency bandwidth effects in relation to the above problem and the
      influence of bandwidth on amplitude indications from test blocks
      commonly used to calibrate equipment sensitivity are discussed. In
      addition, an outgrowth of the above work is a realization of the
      necessity for periodic evaluation of transducers.

1661 ULTRASONIC SCATTERING AND ATTENUATION IN POLYCRYSTALLINE COPPER AND
      BRASS
      D. W. Krautkopf
      Journal of the Acoustical Society of America, July 1960, p. 824-835

      The subject title has been studied with the primary objective being
      that of direct observation of the scattered radiation, and a study
      of attenuation where pulse patterns were caused by excessive scatter-
      ing or mode conversion. Attenuation varied as expected for elastic
      hysteresis damping.

1667 MEASUREMENT OF ULTRASONIC ATTENUATION AS METHOD FOR QUALITY CONTROL
      OF WROUGHT AND CAST STEEL PARTS
      E. Krainer
      Materials Testing-Materiaux Vol. 4, No. 12, December 20 1962,
      p. 463-469

      Summary of theory of interpreting attenuation as indication of
      structural or physical and mechanical properties; examples of appli-
      cation. 35 refs.

1709 ULTRASONIC POLE PATTERNS IN SAE 4150 STEEL
      P. F. Sullivan
      U. S. Army Materials Research Agency, Watertown, Mass.
      WAL TN 143/42, January 1963, 22 p. w/illus.

      The phenomenon of ultrasonic pole patterns arising from double re-
      fraction is explained and preliminary experimental results, graded
      as to reliability, are presented. Special emphasis is placed on
      instrumentation and technique with a thorough analysis of errors
      and detailed suggestions for improvement. The extensive field of
      application of this phenomenon as a tool for testing materials is
      indicated.

1726 SPECIAL TECHNIQUES OF NONDESTRUCTIVE TESTING OF METALLIC WORKPIECES
      H. J. Rodewald and C. Studer
      Metall, Vol. 17, No. 1, January 1963, p. 24-26

      Extension of previous work (see Engineering Index 1961, p. 992);
      immersion apparatus for testing plate by ultrasonic attenuation;
      ultrasonic testing of continuously cast aluminum billets in water
      tank of continuous casting machine; advantages of foil and dis-
      persion lacquer techniques in penetration testing of defects in
      metal surfaces; stereoscopic x-ray testing of welds.

1968   ON THE ATTENUATION OF ULTRASONIC WAVES IN CHROME-NICKEL AUSTENITIC
STEELS
P. Midecke
HB 5115, Materialprufung, Vol. 3, No. 1, 1961, p. 1-4

Application of nondestructive procedures for testing Cr-Ni austenitic
steels is severely limited, since magnetized particle testing fails
completely and ultrasonic testing is difficult and sometimes impossible
for parts some 10 mm (0.4 in.) thick. Compared with unalloyed
structural steels, the propagation of ultrasonic waves is consider-
ably interfered with. With increasing carbon content, Cr-Ni austen-
itic steels contain increasing amounts of precipitates. Because of
the resulting increased acoustical attenuation, an investigation
into the limits of applicability of ultrasonic testing seemed de-
sirable.

1974   INVESTIGATION ON THE MEASUREMENT OF SOUND ATTENUATION AND ULTRASONIC
DETERMINATION OF DEFECT SIZE (IN STEEL FORGINGS)
W. Knorr and H. G. Ricken
HB 5656, Archiv Eisenhuttenwesen, Vol. 33, No. 5, 1962, p. 317-325

The significance of the measurement of sound attenuation and the
determination of defect size lies in the important fact that the
ultrasonic technique has actually been converted into a quantitative
technique and ultrasonic test results can now be interpreted ob-
jectively.

1975   DETERMINATION OF DEFECT SIZE IN FORGINGS BY AN ULTRASONIC TECHNIQUE
P. Opel and G. Ivens
HB 5655, Archiv Eisenhuttenwesen, Vol. 33, No. 5, 1962, p. 311-316

Modification of Krautkramer's technique for the determination of
ultrasonic beam attenuation and defect size in forgings by the use
of the back echo instead of the reference echo.

2058　ULTRASONIC METHODS IN THE STUDY OF FATIGUE AND DEFORMATION IN
SINGLE CRYSTALS OF ALUMINUM AND SODIUM CHLORIDE
B. Chick, et al   N63-15806
Brown University, Providence, R. I.
ASD-TDR-62-186, February 1963

The use of ultrasonic methods for studying defect formation and its
consequences in connection with stress cycling and deformation in
aluminum and sodium chloride single crystals is the subject of this
report. The observed ultrasonic changes appeared closely associated
with changes in dislocation behavior. To establish this deformation,
experiments were used in such a way that results could be related
to the behavior of the slip systems and to their orientation. Im-
portant equipment improvements have been made for automatic record-
ing of attenuation and velocity measurements.

2066　THEORETICAL AND EXPERIMENTAL STUDIES OF PRESSURE PROFILES IN ULTRA-
SONIC WAVEGUIDES
E. F. Carome and J. B. Lastovka
Journal of the Acoustical Society of America, Vol. 35, No. 5, May
1963, p. 645-650

Investigations have been conducted in an attempt to confirm results
of attenuation vs pathlength in liquid-filled waveguides. Theoret-
ical profiles, pressure-free walls and rigid walls were computed.
Experimental results confirm the theoretical predictions for guides
with pressure-free walls.

2101　ULTRASONIC MEASUREMENT TECHNIQUES APPLICABLE TO SMALL SOLID SPECI-
MENS
H. J. McSkimin
Journal of the Acoustical Society of America, July, 1950, p. 413-418

Velocity of propagation measurements and elastic constants may be
conducted by phase comparison at high ultrasonic frequencies for
single crystals or other small solid specimens. The pulse technique
utilizing both longitudinal and transverse waves permits determin-
ation of the wavelengths in the acoustic path, along with measure-
ment of phase shift at reflecting interfaces. Theoretical analysis
is included along with illustrative data.

2107 ULTRASONIC METHODS IN THE STUDY OF FATIGUE AND DEFORMATION IN
SINGLE CRYSTALS
B. Chick et al   N63-18393
Brown University, Providence, R. I.
ASD-TDR-62-186, Pt. II, April 1963, 76 p.

Ultrasonic methods for studying defect formation and motion in con-
nection with deformation and stress cycling experiments in aluminum
and sodium chloride single crystals is the subject of this report.
Large single crystals of sodium chloride, deformed in tension, were
measured similarly to aluminum for the purpose of comparing the
dislocation damping and recovery effects in an ionic crystal with
those in a metal. Also there was significant information from
electrical conductivity measurements made concurrently with atten-
uation and velocity measurements. Al single crystals were also
stress cycled in tension and compression at levels much higher
relative to yield stress and breaking stress than polycrystalline
samples.

2122 METHOD OF MEASURING AND ANALYSING WAVE MOTION
W. K. R. Lippert
Acustica, Vol. 12, No. 3, 1962, p. 125-139, SNT Journal, May-
June 1963

Acoustic propagation parameters, i.e. attenuation constant and
characteristic impedance, of a sample can be determined from
measurable quantities of acoustic waves in the input ducts that
terminate the sample of material. A model sample was used that
consisted of numerous cylindrical tubes in parallel. Measurements
of the reflection and transmission factors (complex) permit the
propagation parameters to be determined. Corrections for transition
zone losses between the duct and the sample can be made by substi-
tuting a plate for the sample, the plate to have the same hole con-
figuration as the sample cross section. Additional measurements
with the plate in place provide information so that corrections in
magnitude and phase can be applied to the propagation parameters.

2217 A METHOD FOR DETERMINING THE PROPAGATION CONSTANTS OF PLASTICS AT
ULTRASONIC FREQUENCIES
H. J. McSkimin
Journal of Acoustical Society of America, Vol. 23, July 1951,
p. 429-434

Description of a technique suited for measuring attenuation and
phase-shift constants in plastics. 5-50 Mc frequencies were uti-
lized with either transverse or longitudinal waves. Data is given
for polyethylene and nylon.

2246 INFLUENCE OF MICROSTRUCTURE IN ULTRASONIC EXAMINATION OF STAINLESS
STEEL WELDS
E. Holmes and D. Beasley
Iron and Steel Institute Journal, Vol. 200, Pt. 4, April 1962,
p. 283-290

Austenitic stainless steel welds have high ultrasonic attenuation
and abnormal beam transmission, thereby complicating flaw detection.
The cause and occurence are discussed. Carbides and ferrite did not
appear to increase scattering when finely divided in large inclusions.

2385 ATTENUATION OF PURE ELASTIC MODES IN NaCl SINGLE CRYSTALS
E. P. Papadakis
Journal of Applied Physics, Vol. 34, No. 7, July 1963, p. 1872-1876

A discussion of dislocations as being the major source of attenuation
in single crystals; pulse echo attenuation for longitudinal and
transverse measurements along 3 pure mode axes in subject specimens.

2554 ULTRASONIC CONTROL OF FATIGUE DAMAGE TO MATERIALS
P. V. Ponomarev
Industrial Laboratory, Vol. 28, No. 11, November 1962
Translation (Russian). Published July 1963, p. 1429-1431

The relationship between the accumulation of fatigue damages in a
material absorption of ultrasonic sound during the process of fatigue
inspection is considered. It is established that the moment of
failure onset of a part can be determined from the character of
change of the ultrasonic attenuation curve. The possibility of cre-
ating an instrument for the continuous or periodic inspection for
fatigue damages of materials is pointed out.

2671 AN IMPROVED BONDING CLAMP AND AUXILIARY EQUIPMENT FOR ULTRASONIC
MEASUREMENTS
P. F. Sullivan
U. S. Army Materials Research Agency, Watertown, Mass.
AMRA TR 64-06, April, 1964

A new bonding clamp for the production and examination of coupling
between an ultrasonic transducer and a specimen is discussed both
from the operational and constructional points of view. In addition
to the clamp itself, auxiliary equipment now in the development stage
is also discussed. Most significant of this equipment is an auto-
matic attenuation monitor which gives a continuous readout of the
ultrasonic attenuation of the specimen. With this apparatus, it is
possible to determine the attenuation as a function of rapidly vary-
ing dynamic conditions.

2910 THE EFFECT OF THE FREQUENCY OF SOUND ON ITS ABSORPTION BY A METAL
IN A MAGNETIC FIELD
M. S. Svirskii
Soviet Physics, JETP, Vol. 17, No. 2, August 1963, p. 426-428

Consideration is given to gigantic quantum oscillators when absorp-
tion of sound by a metal occurs in a magnetic field due to the
variations of frequency. Further experimental possibilities of such
effects are also considered.

2953 INSPECTION OF BURNT STEEL IN CALIBER .30 CARBINE BARRELS
R. D. Korytoski
Springfield Armory, Springfield, Mass.
Tech. Rpt. SA-TR1-1012, 22 April 1957, 12 p.

A serious condition of burnt steel in supplied barrel forgings
necessitated the development of nondestructive test procedures to
detect this condition and to salvage rough forgings, semifinished
and finished barrels manufactured from lots containing this condi-
tion. A number of methods were investigated including visual ex-
amination, magnetic particle, magnetic analysis, dye penetrant and
ultrasonic attenuation. Rapid and reliable inspection procedures
were developed with the use of ultrasonic attenuation techniques.
Approximately 185,000 barrels in various manufacturing stages were
inspected by use of this method. CONCLUSIONS: Proper interpretation
of ultrasonic attenuation patterns provides a method to detect burnt
steel. The method is sensitive, reliable, and rapid. Dye penetrant
methods provided means of detecting burnt steel in semifinished
barrels; however, the methods were not economical because of the
time required for application. Visual method of inspection after
etching or pickling process was useful in the establishment of
standards for the ultrasonic attenuation method, but by itself was
neither reliable nor practical for 100% inspection. Methods uti-
lizing comparison of magnetic properties could not be applied in
inspection of burnt steel since correlation did not exist between
magnetic test results and microscopic examinations.

3039 AN INVESTIGATION OF ULTRASONIC INSPECTION METHODS FOR SINTERED
POWDERED METAL COMPACTS
R. D. Korytoski and E. H. Abbe   AD-252184
Springfield Armory, Springfield, Mass.
3 October, 1960, 34 p.

Progress is reported on a continuing study to determine the feasi-
bility of utilizing ultrasonic attenuation methods in nondestructive
inspection of cast and sintered small arms components. Studies are
summarized concerning techniques and equipment designed and developed
for ultrasonic measurement of cast, sintered, and wrought ferrous
material. Influence of variables such as density, grain size, sur-
face preparation, filler substances, degree of sintering, and speci-
men geometry on ultrasonic attenuation is discussed.

3062 ULTRASONIC INSPECTION USED TO DETECT HYDROGEN ATTACK
J. Bland
Petroleun Refiner, July 1958, also Sperry Reprint 50-875

An ultrasonic method is presented which is capable of detecting dam-
age produced in steel by high temperature hydrogen attack. Previ-
ously this method had been used successfully to detect burning in
aluminum. Normal multiple back reflections can be obtained on sound
material, whereas damaged areas so attenuate the signal that no back
reflection or a reduction in the back reflections is received.

3071 ULTRASONIC TECHNIQUES FOR INSPECTING PLASTICS
J. B. Ramsey
Automation Industries, Inc.
Western Plastics Magazine, Technical Report No. 100, September 1963,
p. 33-35

This is a good introductory article on the subject of ultrasonic
testing of plastics. It covers acoustic impedance and attenuation,
modulus of elasticity, density, and Poisson's Ratio. Several examples
of plastics tested are given and the three common methods for ultra-
sonic testing are explained. They are: direct reflection, reflector
technique, and through transmission. Several figures are included,
including a C-scan presentation of an unbonded plastic-steel point.

3086   ULTRASONIC ATTENUATION STUDIES OF DIE BLOCK STEELS
        R. D. Korytoski and R. H. Brockelman
        Springfield Armory, Springfield, Mass.
        Report SA-TR-19-1513, December 1964

        This investigation was undertaken to determine the feasibility of
        using ultrasonic attenuation measurements to nondestructively
        evaluate die block steels for other than gross defects. Both pulse
        echo and comparator type measurement were made on samples of die
        block steels in various conditions of heat treatment. Observed
        attenuation values correlated with the prior austenitic grain size
        of hardened and tempered specimens. Variations of attenuation within
        die blocks were used as an indirect measure of structural uniformity.
        The method appears to be feasible for the evaluation of certain con-
        ditions in die blocks.

3112   THE USE OF ULTRASONIC METHODS TO DETERMINE FATIGUE EFFECTS IN METALS
        R. Truell, B. Chick et al
        Metals Res. Lab., Brown University, Providence, R. I., Contract
        AF-33(616)5884, Rpt. for 16 June 58-15, June 1959, 23 p.

        An investigation was made to detect and follow physical changes in
        materials, primarily Al, during stress cycling by means of high
        frequency ultrasonic attenuation and velocity measurements. A dis-
        cussion is presented of observed changes in ultrasonic attenuation
        and velocity in commercially pure 1100 Al (Alcoa) when subjected
        to slow continued stress cycling (1 to 6000 c) and a delayed re-
        covery phenomenon that appeared when the cycling was interrupted.
        The development of an automatic instrument to measure and record
        ultrasonic attenuation changes is also discussed.

3126   ULTRASONIC ATTENUATION AND VELOCITY MEASUREMENTS IN QUARTZ
        T. Fitzgerald and R. Truell   AD-257 086
        Metals Res. Lab., Brown University, Providence, R. I., 4 May 1961,
        30 p.

        The frequency dependence of the attenuation of compressional waves
        in X-cut quartz obeys an approximate square law consistent with the
        dislocation damping theory which predicts a square-law frequency
        dependence up to a resonant frequency. The behavior of the atten-
        uation as a function of temperature below 100 K is in agreement
        with that predicted by a phononphonon process. Above 40 K the ther-
        mal conductivity varies approximately as $1/T$ while the specific heat
        increases linearly with the temperature between 40 and 150 K. The
        temperature dependence of the velocity measured in this experiment
        indicates that it remains constant at a value of 5.75 K X 10 to the
        6th power cm/sec to within + or - 0.02%. In the region where the
        attenuation is rapidly changing there is apparently no associated
        velocity change.

3168 ULTRASONIC ATTENUATION IN SUPERCONDUCTORS
T. Tsuneto   AD 257 610
Illinois University, 31 August 1960, 14 p.,
TR-22

A general treatment of ultrasonic attenuation of both longitudinal
and transverse waves in super conductors, valid for an arbitrary
mean free path, is given on the basis of the Bardeen-Cooper-
Schrieffer theory. The interaction between the ultrasonic waves
and electrons is assumed to be given by a self-consistent electro-
magnetic field. Instead of the customary theory of the attenuation
based on the Boltzmann equation, a different formulation is developed
using the density-matrix formalism. The ratio of the attenuations
in superconducting and normal metals for the longitudinal wave turns
out to be approximately independent of the mean free path. The
attenuation of the shear wave due to electromagnetic interaction
shown to be very small in the superconducting state.

3198 ATTENUATION OF SOUND IN A GERMANIUM CRYSTAL AT ULTRA-HIGH FRE-
QUENCIES AND LOW TEMPERATURES   AD 254 572
E. R. Dobbs, B. B. Chick and R. Truell
Metals Res. Lab., Brown University, Providence, R. I., 29 June 1959,
3 p. (Reprint from Physical Review Ltrs 3:332-334, 1 October, 1959)

The ultrasonic attenuation of compressional and shear waves in a
high-purity crystal of germanium were measured at frequencies up to
650 mc and at temperatures down to 1.5 K. At room temperature there
is some evidence for the dislocation loss mechanism, but at low
temperatures the attenuation is very small. The specimen was of
n-type germanium, with room temperature resistivity 45 ohm-cm and
net donor concentration 1 x 10 to the 12 power/cc.

3261 THE PROPAGATION OF ULTRASONICS IN SUSPENSIONS OF LIQUID GLOBULES IN
ANOTHER LIQUID
P. A. Allison, E. G. Richardson
Proceedings of the Physical Society, Vol. 72, Part 5, No. 467, p. 883,
November 1958

Studies conducted on ultrasonic attenuation of two liquids mixed to-
gether, one containing globules in suspension. Effects of viscocity
of the liquid and globules on attenuation is studied. Relevant fac-
tors include scattering and pulsation of the globules.

3262 THE PROPAGATION OF ULTRASONICS IN SUSPENSION OF PARTICLES IN A
LIQUID
J. Busby, E. G. Richardson
Proceedings of the Physical Society, Vol. 69, 1956, p. 193

The measurement of sound propagation of solid particles in suspension
in water using frequencies of 1 to 10 Mc/s is described. Results
are in good agreement with theory. Absorption is linear up to a
concentration of 18% by volume with glass or silica particles in
suspension.

3286 ULTRASONIC PROPAGATION IN LIQUID AMMONIA AND AMMONIA SOLUTIONS OF
SODIUM BROMIDE, SODIUM IODIDE, LITHIUM AND SODIUM METAL
E. J. Zdanuk   AD-101 737
Boston University, Boston, Mass., 19 March 53-31, March 1956, 51 p.

The velocity and attenuation of sound in liquid ammonia and solutions
of electrolytes and metals have been measured by the pulse technique
from 4 to 52 megacycles over the temperature range -35° to -70°C.
The high velocity of sound in ammonia does not support the pre-
dictions of free volume theory. The attenuation in ammonia exceeds
the calculated classical attenuation. The ratio obs./calc. for
ammonia is consistent with the properties of an associated liquid.
The velocity of sound in ammonous NaBr and NaI solutions relative
to pure solvent and the corresponding adiabatic compressibilities
resemble the nature of these properties in aqueous systems and are
qualitatively explainable in terms of the electrostrictive concept
of ionic solutions. The attenuation of sound in the salt solutions
was substantially larger than in corresponding aqueous solutions.
In ammonia solutions of Na and Li, the decreases of velocity with
increasing concentration are 3 to 5 times the decreases observed
for NaI at equivalent concentrations. The compressibilities of the
metal solutions increase with concentration in contrast with the
decreases observed for aqueous or ammonous electrolytic solutions.
This behavior is tentatively explained in terms of an expanded metal
structure consisting of ammoniated positive ions and ammoniated
electrons in a quasi lattice in which the electrons still serve as
bonding electrons giving the system its cohesive energy. The atten-
uation of sound in the metal solutions exceeds the classical pre-
diction. In addition a maximum in the attenuation dependence on
concentration was indicated which may be indicative of electron pairing
equalibria in the metal solutions.

3300 THE FREQUENCY DEPENDENCE OF ULTRASONIC ATTENUATION IN GERMANIUM
A. Granato and R. Truell   AD 91634
Metals Research Lab., Brown University, Providence, R. I.
Tech Rpt, March 1956, 32 p.

The frequency dependence of the ultrasonic attenuation of compres-
sional waves propagating in the (100) direction in Ge were measured,
and 2 components were separated. The first is a result of diffrac-
tion and is the principal loss at lf's. The second is a loss which
increases almost with the square of the frequency up to 300 mc and
can be accounted for with reasonable values of the dislocation den-
sity and loop length. A damping constant (B) range of 8 x 10-5 =
B = 14 x 10-5 was computed for a loop length (L) range of 8 x 10-5
= L = 10-4 cm. A percentage modulus change (E/E) of 0.013% was
calculated for a dislocation density ( ) of 19-6 cm -2 and an L of
9 x 10 cm. The LF expression for the attenuation B = 3 x 10-17-2
db/usec was obtained for = 3.7 x 10-6 cm -2, L = 9 x 10-5 cm, and
B = 1.1 x 10-4 where f is the frequency. Measurement of the atten-
uation of shear waves propagated in the 100 direction indicated a
double refraction effect. Specimens with high compressional wave
attenuations also appeared to have high shear-wave attenuations.

3303 TRANSMISSION OF ULTRASONIC VIBRATION IN METALS
R. W. Mebs   AD 92 032
National Bureau of Standards
Quart Rpt. No. 3, 1 January 1931, March 1956, 25 April, p. 24

Measurement of ultrasonic transmission was continued on 1/2-, 1-,
20-, and 3-in. test specimens of SAE a4340 steel at 10 mc for 1-,
30-, and 7-usec nominal pulse lengths. The crystals originally
attached to the buffer lines appeared to be in satisfactory condition.
Tests were completed on SAE 4340 steel in the air-cooled condition,
as furnace cooled from 1550°F, and after double tempering subsequent
to oil quenching from the austenitizing temperatures of 1550°F and
1650°F, respectively. Tests were also completed on isoleastic alloy
F in the as received condition. Only net values of attenuation and
delay time are recorded. A survey of values of pulse length and rise
time indicated no significant variation of output pulse shape as
obtained with the buffer lines in comparison with those obtained with
a successively increasing length of test specimens. The principal
distortion of the sent pulse appeared to occur in the transducer.
Curves are presented of the variation of net attenuation with speci-
men length for the 2 as received materials, which indicate an in-
crease in attenuation with length. Attenuation length curves were
obtained for air-cooled SAE 4340 steel demagnetized at 60 cycles
and remagnetized with a force of about 500 oer; remagnetization
lowered the attenuations of all but the 3 in. specimen below the
values obtained before demagnetization. Slopes of the net delay
time length curves for SAE 4340 steel as received and after various
heat treatments were almost identical. (See also AD 83 783).

3306 ACOUSTICAL RESEARCH
R. B. Lindsay   AD-104 544(a) - AD-104 544(h)
Brown University, Providence, R. I.
Technical Report No. 8, July 1956

Underwater sound reflection from a corrugated surface. Relative
absorption of 10mc/sec longitudinal sound waves in a superconducting
polycrystalline tin rod. Pressure coefficient of the dielectric
constant of water. Ultrasonic attenuation in superconducting indium.
On the application of the kinetic theory of liquids of Born and
Green to the problem of the calculation of the volume viscosity.
Propagation of sound pulses in a dispersive medium. Tank wall lining
for underwater sound use. Vibrational relaxation in N_2O - H_2O and
N_2O - D_2O mixtures.

3325 ORIENTATION DEPENDENCE OF ULTRASONIC ATTENUATION IN ZINC
P. C. Waterman   AD-206 161
Metals Res. Lab., Brown University, Providence, R. I., 24 January
1958, 6 p.

The attenuation of plane elastic waves in the megacycle region is
investigated for several different propagation directions in single
crystalline zinc. Results are in qualitative agreement with the
losses predicted theoretically due to dislocation damping and
thermoelastic effects, and in addition losses not accounted for by
the available theory are observed.

3407 AN EXPERIMENTAL SYSTEM FOR ULTRASONIC ATTENUATION, MEASUREMENTS IN
SOLIDS IN THE UPPER KILOCYCLE RANGE
R. E. Booker, F. H. Sagar
University of Auckland
Ultrasonics, Vol. 1, October - December 1963

The measurement of acoustic attenuation in small samples of low loss
solids in the range 50 kc/s to 10 mc/s has, up to now, proven dif-
ficult. When the pulse method is applied below 10 mc/s it is not
easy to perform satisfactory corrections for diffraction and mode-
conversion errors. The resonance method, in the form most fre-
quently used, is suitable for elastic constant and attenuation
measurements over the lower part of the kilocycle range, i.e., 1-
20 kc/s. This paper is an account of various modifications in the
experimental set-up of the resonance method of attenuation measure-
ments, whereby good signal/noise ratios have been realized up to
700 kc/s attenuation measured from 20 kc/s to 600 kc/s, and output
signals generated from 0-5v down to 10 micro v.

3451 INVESTIGATION OF ULTRASONIC SURFACE WAVE PROPAGATION ALONG THE
BOUNDARY BETWEEN LIQUID AND SOLID
I. A. Victorov
Akust. Zh. 9, No. 2, 1963, Ultrasonics, October-December 1963

Automatic NDT by ultrasonic immersion techniques offers many advan-
tages, and in this article the effect of the immersion liquid on
the characteristics of surface waves are investigated both theoret-
ically and experimentally. Velocity and attenuation in steel and
aluminium immersed in water, transformer oil and glycerine were
studied at a number of frequencies, and there was agreement of about
10-15% between theoretical and experimental results. (1 table, 6
figures, 3 references). In a consecutive paper (p. 171) Victorov
and Zubova present an experimental and theoretical study "On
directivity patterns of Lamb's and Rayleigh's wave radiators."

3457 FREQUENCY DEPENDENCE OF ULTRASONIC ATTENUATION AND VELOCITY ON
PLASTIC DEFORMATION
A. Hikata, R. Truell
Brown University, Providence, R. I.

The dependence of ultrasonic attenuation and velocity on plastic
deformation in 2S aluminum is compared at two frequencies, five and
ten megacycles, and the comparison shows agreement as regards to
frequency dependence with what one can expect from dislocation
damping theory.

3471 FEASIBILITY STUDY TO DETERMINE WHETHER ULTRASONIC TECHNIQUES CAN BE
USED TO MEASURE MECHANICAL PROPERTIES OF CAST POLYURETHANES INTENDED
FOR APPLICATION AS SOLID PROPELLANT BINDERS
Aeronautical Systems Division, Physics Lab, Wright-Patterson AFB
Report No. ASD-TDR-62-886, Final Report, July 1963, 32 p. w/illus.

The purpose of this project is to determine the feasibility of
utilizing ultrasonic techniques to measure mechanical properties
of cast polyurethanes. Two suppliers prepared and delivered several
series of specimens simulating both binder and propellant materials
in various conditions of aging. Sperry Products performed ultrasonic
examination of these specimen materials with the objective of find-
ing ultrasonic properties which would indicate their physical con-
dition. Results of tests indicate a significant dependence of both
shear wave attenuation and relative acoustic impedance of certain
specimen materials on their condition of aging.

3493 DETERMINATION OF COMPLEX MODULI OF VISCOELASTIC MATERIALS WITH
ULTRASONIC PULSE METHOD
H. A. Waterman
Kolloid-Zeit, Vol. 192, No. 1-2, October 1963/II, p. 1-16

Real and imaginary parts of 2 independent elastic moduli can be
found from velocity and attenuation of ultrasonic waves as measured
with aid of modified rotating plate method introduced by Y. Maeda;
measurements on isotactic polypropylene and high density poly-
ethylene; measurements of velocity and attenuation of longitudinal
and transverse waves in polyethylenes. 26 refs.

3587 PRECISION ULTRASONIC MEASUREMENTS FOR MICROBUBBLE RESEARCH
W. R. Turner   AD 413052
Vitro Laboratories, Silver Spring, Md., July 1963

New techniques are described for measuring ultrasonic attenuation
and velocity in water at 3 frequencies in the 1-10 mc range. Basic
instrument configuration is that of a Mach-Zehnder type interferom-
eter, w/ one path including an ultrasonic cell, the other a pre-
cision attenuator. The cell consists of a 3 frequency transducer,
a supporting cage, and a reflector. In operation a signal is
switched for a short time to the cell then returned to the atten-
uator path. The pulse is delayed by transit through the cell, is
mixed w/ the attenuator signal to obtain a null and displayed on a
CRT. Attenuation is determined from the attenuator setting, and
velocity from the frequency interval between nulls.

3588 COMPARISON OF ULTRASONIC EFFECTS IN PIEZOELECTRIC AND SIMPLE DE-
FORMATION POTENTIAL SEMI-CONDUCTORS
J. Mertsching
Physica Status Solidi, Vol. 4, No. 2, 1964, p. 453-458

Ultrasonic attenuation or amplification and acousto-electric field
in nonpiezoelectric semiconductor with large deformation potential
are obtained from data on piezoelectric semiconductor, piezoelectric
field being replaced by deformation potential field and by adding
new term to sound velocity.

3596 SIMULTANEOUS MEASUREMENT OF ULTRASONIC ATTENUATION AND YIELD STRENGTH
OF Mg SINGLE CRYSTALS
W. F. Chiao, R. B. Gordon
Applied Physics Letters, Vol. 3, No. 5, September 1 1963, p. 88-89

Sharp yield occurs when stress in some part of test specimen be-
comes great enough to unpin dislocations, after which plastic flow
propagates rapidly through sample; one of major contributions to
total ultrasonic attenuation, α in metal single crystal is from
dislocation damping; 2 phenomena can be related; strain-stress
curves for single Mg crystal are related to ultrasonic attenuation
observed during deformation.

3604 DIFFRACTION OF ULTRASOUND RADIATION INTO AN ELASTICALLY ANISOTROPIC
MEDIUM
E. Papadakis
Bell Telephone Laboratories, Inc., Allentown, Penn. October 1963
Reprint, Journal of the Acoustical Society of America, Vol. 36, No. 3,
March 1964

This article discusses the scaled diffraction loss-distance charac-
teristics as a use for computing diffraction corrections for ultra-
sonic attenuation. Ultrasonic pulse echo, diffraction loss-distance
characteristics for various crystal anisotropics are computed.

3637 ULTRASONIC ATTENUATION AND THE PHYSICS OF SOLIDS
R. Truell
Brown University, Providence, R. I.
Symposium on Physics and Nondestructive Testing, Argonne National
Laboratory, 1960, p. 109-126

An outline is given of those interactions between ultrasonic stress
waves in solids and the various types of absorbing or scattering
elements which can be studied by observing the propagation behavior
of the stress waves. A discussion will be given of what can be
learned about solids and defects in solids from the physical point
of view. Specific examples related to changes in mechanical proper-
ties and changes induced by radiation effects are given.

3693   FEASIBILITY STUDY TO DETERMINE WHETHER ULTRASONIC TECHNIQUES CAN BE
        USED TO MEASURE MECHANICAL PROPERTIES OF CAST POLYURETHANES INTENDED
        FOR APPLICATION AS SOLID PROPELLANT BINDERS
        A. M. Murdock, H. E. Van Valkenburg   AD 415828
        Aeronautical Systems Div. Dir/Materials and Processes, Physics Lab.
        Wright-Patterson AFB, Ohio
        RPT. No. ASD-TDR-62-886, Final Rpt, July 1963, 32 p.

        The purpose of this project is to determine the feasibility of uti-
        lizing ultrasonic techniques to measure mechanical properties of
        cast polyurethanes. For this project 2 suppliers prepared and de-
        livered to Sperry Products several series of specimens simulating
        both binder and propellant materials in various conditions of aging.
        Sperry Products performed ultrasonic examination of these specimen
        materials with the objective of finding ultrasonic properties which
        would indicate the materials' physical conditions. Results of test
        indicate a significant dependence of both shear wave attenuation and
        relative acoustic impedance of certain specimen materials on their
        condition of aging.

3695   ATTENUATION OF ULTRASONIC STRESS WAVES IN CADMIUM SULFIDE CRYSTALS
        G. F. Heinrich, Capt: USAF   AD 418558
        Air University USAF, Wright-Patterson AFB, Ohio, August 1963

        Velocity and attenuation of pulsed, ultrasonic stress waves in 5 cad-
        mium sulfide crystals, 3 of which were "tap effect" crystals, were
        measured at frequencies of 5 and 10 mc/sec, at temperatures of 77°K
        and 300°K. Velocity and attenuation measurements were taken while
        crystal was irradiated with different, discrete, wavelength light in
        directions parallel to and perpendicular to the C-axis. Attenuation
        of stress waves was proportional to the conductivity when the stress
        waves were propagated parallel to C-axis at 300°K. Attenuation
        wasn't a function of conductivity when stress waves were propagated
        perpendicular to C-axis. Attenuation was greater at 77°K than
        attenuation at room temperature. 300°K attenuation results on all 3
        "tap effects" crystals were similar to the results that Truell and
        Nine obtained on their so-called type "B" cadmium sulfide crystals.

3760 ULTRASONIC METHODS IN THE STUDY OF DEFORMATION IN SINGLE CRYSTALS
B. Chick, A. Hikata, G. Anderson, C. Elbaum, R. Truell   AD 606759
Brown University, Providence, R. I.   N65-13435
Wright-Patterson Air Force Contract No. AF 33 (657)8324.
Rpt. No. ML-TDR-64-34, March 1964

The purpose of this investigation is that of understanding the
physical changes which occur in aluminum and in certain ionic crystals
during and after deformation. The investigation involves the study
of imperfection behavior generally, and specifically the interaction
of point defects with moving and vibrating dislocations, as well as
the contribution of dislocations to the anharmonic characteristics
of solids. Experiments were carried out on the recovery of ultra-
sonic attenuation following plastic deformation and as a function of
plastic strain.

3779 GRAIN SIZE MEASUREMENTS IN URANIUM BY USE OF ULTRASONICS
H. L. Dunegan
University of California, Livermore, California
Materials Evaluation, August 1964

Ultrasonic attenuation and velocity measurements were made on poly-
crystalline uranium specimens of varying grain size. The major con-
tribution to the attenuation is shown to be due to a scattering
mechanism created by the anisotropic grain orientation. It is also
shown that this attenuation is very sensitive to small changes in
grain diameter, and thus can be used as a quantitative nondestructive
measurement of grain size. A description is given of the specimens,
mechanical fixturing, and electronic instrumentation for making these
measurements. Some basic theory on the attenuation of sound is also
included.

3822 STUDY OF THE ELECTRONIC PROPERTIES OF METALS BY ULTRASONICS
J. D. Gavenda
University of Texas
Proc. of Symposium on Physics and NDT Testing, October 1962
Southwest Research Institute, San Antonia, Texas

It is now realized that ultrasonic attenuation in pure metals at low
temperatures is caused primarily by the interaction of conduction
electrons with the lattice and can be measured directly. This paper
outlines the technique and illustrates its use with specific metals.

3842   ULTRASONICS, A SOLID STATE RESEARCH TOOL
       N. G. Einspruch
       Texas Instruments Incorporated
       Proc. of the Symposium on Physics and NDT Testing, October 1963
       Southwest Research Institute, San Antonio, Texas

       A review of the use of ultrasonics in elucidating the physical
       properties of metals (normal conductors, superconductors), magnetic
       materials, semiconductors and insulators is presented in terms of
       the interactions observable in ultrasonic velocity and attenuation
       measurements. Experiments on electron-phonon interactions, and
       defect-phonon interactions are discussed in detail.

3854   RESIDUAL STRESS STUDIES IN FERROMAGNETIC MATERIALS IN ULTRASONICS
       D. Mills and W. J. Bratina
       Ontario Research Foundation and University of Toronto
       Proc. of the Symposium on Physics and NDT Testing, October 1963
       Southwest Research Institute, San Antonio, Texas

       The internal stresses in ferromagnetic materials were studied by
       means of magneto-mechanical component of ultrasonic wave attenuation.
       The approach is based on a very marked difference in attenuation
       characteristics of an annealed and cold worked material. The latter
       was found to exhibit a characteristic attenuation maximum at a
       definite value of applied stress or magnetic field. The attenuation
       is highly sensitive to the presence of internal stress, and the
       magnitude of stress is related to the position of the maximum. The
       structure and mobility of the domain walls are affected by the changes
       in dislocation density, and associated magneto-mechanical losses
       are expected to change accordingly. The maximum in the damping
       observed in cold worked ferromagnetic materials at low and kilocycle
       frequencies are briefly discussed.

3885   ULTRASONIC NONDESTRUCTIVE TEST FOR THE DETECTION OF IMPROPER HEAT
       TREATMENT OF STEEL
       E. P. Papadakis
       Bell Telephone Labs., Allentown, Pa.
       Materials Evaluation, March 1965

       An ultrasonic test is proposed to determine whether the cycle of
       hardening and tempering steel parts has been carried through properly.
       The test depends upon the changes in ultrasonic attenuation occurring
       upon change of the grain size and microstructure of steel. Failure
       to heat sufficiently to reach the minimum austenitizing temperature
       may leave the attenuation 100 times higher than in tempered martensite.
       The ultrasonic attenuation test method samples the body of the part,
       not just its surface. This ultrasonic method is compatible with
       automated processes.

3913   DETERMINATION OF EFFECT OF MATERIALS AND PROCESS VARIABLES ON FILA-
        MENT WOUND STRUCTURES
        B. E. Chester
        Aerojet General Corporation, Azusa, California
        U. S. Naval Applied Science Lab, Contract No. N140 (131)-75687B (X)
        Progress Rpt. No. 0827-02-2 (quarterly)

        Sixteen 3.0 inch I.D, by 6.0 inch long glass composite test specimens
        having 0.375 inch thick walls were fabricated using machine wrapped
        filaments. Ultrasonic data, void content, calculations, and micro-
        photographs from the test specimens tend to support the theory
        established on other programs that a high ultrasonic attenuation
        indicates high void content.

3934   ULTRASONIC DETECTION OF CHANGES IN THE ELASTIC PROPERTIES OF A 70-30
        IRON-NICKEL ALLOY UPON HEAT TREATMENT
        E. P. Papadakis and E. L. Reed
        Journal of Applied Physics, Vol. 32, April 1961, p. 682-687

        Ultrasonic attenuation and velocity measurements by the pulse echo
        method after various steps in their transformation from austensite
        to martensite. Attenuation from Rayleigh scattering decreased, while
        that from elastic hysteresis increased as the transformation proceeded.
        Presence of small martensite platelets in the grains reduced aniso-
        tropy of elastic constants of the grains, thus reducing the Rayleigh
        scattering. Increase in hysteresis parallels the increase the resid-
        ual strain and the increase in grain boundary material attending the
        transformation.

3956   ULTRASONIC ATTENUATION IN METALS
        R. W. Morse
        Paper from "Seventh International Conference on Low Temperature
        Physics, Proceedings". University of Toronto Press, Canada, 1961,
        p. 233-239

        Review of experiments on the interaction between ultrasonics and
        electrons in metals at low temperature by observation of an atten-
        uation of ultrasonic waves by electronic which occurs when the elec-
        tron free path is comparable to or greater in size than the
        ultrasonic wave length. Application of attenuation measurements to
        determination of Fermi surface, superconducting energy gap, anisot-
        ropy and possibility of an acoustic factor in Au, Ag, Sn and Cu
        single crystals at 1.2°K. 9 ref.

4012 DAMPING MEASUREMENTS ON CAST STEEL WITH A SOUND-IMPULSE APPARATUS
S. Kippa
Giessereitechnik (German), Vol. 9, June 1963
Materials Evaluation, October 1963

Comparative measurements of the sound attenuation in annealed and
nonannealed specimens of GS 38-9 Cast steel of given impulse tester,
in order to develop a simple nondestructive test for distinguishing
between annealed and nonannealed steels.

4015 ULTRASONIC INTERNAL CONICAL REFRACTION IN ROCKSALT AND CALCITE
E. P. Papadakis
Journal of Applied Physics, Vol. 34, August 1963
Materials Evaluation, October 1964

Evidence for the existance of rocksalt and calcite single crystals
was obtained by observing the behavior of shear waves along one of
the axes of threefold symmetry in each crystal. A method of selec-
tive absorption was used in conjunction with pulse-echo ultrasonic
attenuation measurements. Absorbing materials were pasted at various
spots on the bottom of the specimen opposite the transducer to mop
the energy density in the wave. Positions of maximum flux coincided
with predictions when the shear wave was not perturbed by nusorien-
tation-induced ultrasonic double refraction.

4097 ULTRASONIC ATTENUATION IN SUPERCONDUCTORS CONTAINING MAGNETIC
IMPURITIES
L. P. Kadanoff, I. I. Falko
University of Illinois, Urbana, Ill. 13 July 1964
The Physical Review Vol. 136-30 Nov. 1964

In this calculation several electronic time-dependent correlation
functions are evaluated, and these functions are then used to
evaluate the attenuation. In the limit of low sound frequencies,
coefficients are expressed in terms of a single energy integral.
Attenuation in the limit of low temperatures is evaluated for super-
conductors.

4098   ULTRASONIC ATTENUATION IN METALS IN THE FLUID-DYNAMIC APPROXIMATION
        L. H. Hall
        University of California, Santa Barbara, California.
        The Physical Review, Vol. 136, No. 4a, Nov. 1964

        Studies are undertaken on low-frequency range which makes contact with
        the transport-theory formalism of classical gares. "Fluid"-dynamic
        equations for metal are presented. Acoustic attenuation coefficient
        for a longitudinal wave is outlined and thermal and diffusion effects
        are explicit.

4109   COMPLEMENTARY EQUIPMENT TO ULTRASONIC FLAW DETECTORS ALLOWING ATTEN-
        UATION MEASUREMENTS IN THE FREQUENCY RANGE 10-100 Mc/s
        H. Wehr
        Polish Academy of Sciences, Warsaw, Poland
        Proc. of the Fourth International Conf. on NDT, published by
        Butterworth Inc., Washington, D. C., September 1963, p. 162-163

        A simple and compact unit is described for generating, transmitting,
        and receiving ultrasonic pulses in the frequency range of 10-100 Mc/s.
        It permits the measurement of velocity and attenuation of ultrasonic
        waves in liquid and solids.

4110   DETERMINATION OF TENSILE STRENGTH OF CAST IRON BY ULTRASONICS
        J. A. F. Jarvis
        Internations Meehanite Metal Co., Epson, Surrey
        Proc. of the Fourth International Conf. on NDT, published by
        Butterworth Inc., Washington, D. C., September 1963, p. 173-175

        This article briefly covers the use of the relationship between the
        velocity of the ultrasonic energy and the tensile strength of cast
        iron. The absorption or attenuation technique is used by comparing
        a known standard specimen with those parts undergoing tests. This
        simple technique has been used on hundreds of thousands of castings
        without customer refect for low tensile.

4112   QUALITY CONTROL OF STEEL PRODUCTS BY DETERMINATION OF SOUND ATTEN-
        UATION
        E. Krainer
        Gebr. Bohler & Co., Kapfenberg, Austria
        Proc. of the Fourth International Conf. on NDT, published by
        Butterworth Inc., Washington, D. C., September 1963, p. 180-184

        The field of nondestructive testing is not limited to flaw detection
        but also includes evaluation of physical properties of metals. De-
        termination of resistivity, permeability, etc. are already well
        known methods. Ultrasonic attenuation and its evaluation of the
        physical properties of steel products is discussed in this report.

4114   ULTRASONIC ATTENUATION DURING CYCLIC STRAINING
        Z. Pawlowski
        Polish Academy of Science, Warsaw, Poland
        Proc. of the Fourth International Conf. on NDT, published by
        Butterworth Inc., Washington, D. C., September 1963, p. 192-195

        This paper describes the attempt made to connect the parameters
        characterizing the attenuation of ultrasonic waves with certain
        characteristics of the fatigue properties of metals. The knowledge
        of the changes in internal friction and their connection with an
        appropriate stage of fatigue may become a basic for nondestructive
        tests to eliminate the risk of failure due to fatigue.

4154   ELASTIC PROPERTIES OF POLYCRYSTALLINE TUNGSTEN AT ELEVATED TEMPER-
        ATURES
        B. T. Bernstein   N62-16321
        Union Carbide Research Inst., Tarrytown, N. Y.,
        In its Research on Physical and Chemical Principles Affecting High
        Temperature Materials for Rocket Nozzles.
        Qtly. Rpt. July to September 1962, Repr. from J. Appl. Phys., Vol. 33,
        No. 6, June 1962

        An ultrasonic pulse-echo technique was used to measure velocities
        of compressional and shear waves at 10 mc in polycrystalline swaged
        tungsten. Ultrasonic velocities were used to calculate the elastic
        moduli. Results are presented for the temperature dependence of the
        elastic properties of the tungsten at elevated temperatures. Shear
        velocity and modulus decrease smoothly with increasing temperature,
        except in the range 600° to 800°C where the decrease is more rapid.
        Relative attenuation of echo amplitude also shows an anomaly in the
        temperature range 650° to 900°C. Above 1280° shear wave attenuation
        is so great that measurements are not possible. The compressional
        velocity was also shown to decrease smoothly with increasing temper-
        ature. Measurements on single crystals and chemically analyzed high
        purity polycrystalline tungsten are planned in order to help resolve
        the damping mechanism.

4180 ULTRASONIC SPECTROSCOPY OF STEEL
      O. Gericke   AD 614 113
      U. S. Army Materials Research Agency, Watertown, Mass.
      AMRA TR 64-44, December 1964.

      An electronic instrument has been developed which makes it possible
      to obtain the ultrasonic attenuation spectrum of a solid material.
      The spectroscope employs the ultrasonic pulse-echo test technique
      and is equipped with a single ultrasonic transducer which is used for
      both transmission and reception of ultrasonic signals. The ultrasonic
      spectroscope has been applied to examine microstructures of steel
      specimens differently heat treated to produce grain size variations.
      Experimental results indicate that the amplitude distribution in the
      ultrasonic spectrum is strongly influenced by specimen microstructure.
      It is possible to discriminate between grain sizes varying from 2 to
      8 (ASTM Scale).

4206 THE CORRELATION OF DESTRUCTIVE AND NONDESTRUCTIVE TESTING OF HEAVY
      STEEL CASTINGS WITH PARTICULAR REFERENCE TO ULTRASONIC EXAMINATION
      J. D. Lavender
      British Steel Casting Research Association, Iron & Steel, June 1964.
      Iron & Steel Prize 1964. Presentation, Sheffield Metallurgical and
      Engineering Association

      Results obtained from this report show that the ultrasonic detection
      method has a far greater sensitivity to minor inhomogeneities in cast
      steel than does high resolution X-ray or gamma ray techniques. Cor-
      relation between ultrasonic attenuation measurements and mechanical
      data is included.

4269 THE ULTRASONIC ATTENUATION IN METALS. METHOD OF MEASURING BY PULSE
      TECHNIQUE AND ANALYSIS OF THE EXTERNAL LOSS DUE TO COUPLING
      M. Robba
      Alluminio, Vol. 32, No. 9, September 1963, p. 421-431

      Measurement of the ultrasonic attenuation in Ergal 65 and SAP Al
      alloys by pulse technique, by direct coupling and by water immersion.
      It is found that the energy loss increases due to the action of the
      coupling medium on the impulse reflection.

4273 FATIGUE LIMIT AND ITS DISPERSION
Z. Pawlowski
Przegl Spawalnictwa, Vol. 16, No. 7-8, 1964, p. 161-173

Examples given for the statistical estimation of life and strength
distributions in the region of fatigue and endurance limit of Al-
Mg-Si alloy and gray cast iron. Results of Probit, Staircase and
Cocati methods compared. Results obtained indicate that the cumula-
tive damage differs from unity. The proper value of the cumulative
damage was determined on the basis of measurements of ultrasonic
waves attenuation during cyclic straining.

4277 TEMPERATURE DEPENDENCE OF THE ULTRASONIC ATTENUATION IN GERMANIUM
B. L. Miller
Physical Review, Vol. 132, No. 6, December 15, 1963, p. 2477-2483

The ultrasonic attenuation in Ge is measured as a function of temper-
ature from $20°$ to $300°K$, and at frequencies of 4 to 132 Mc/sec. The
measurements are made using the pulse echo technique with longitudinal
sound pulses along the (111) direction.

4308 ULTRASONIC INSPECTION OF SPOT-WELDED ALUMINIUM ALLOYS
I. V. Vavulo
Welding Production, No. 7, July 1962, p. 63-66.

Effectiveness of ultrasonic inspection for detecting lack of fusion
in spot welds in D16, V95, and AMg^6Al alloys. Attenuation of ultra-
sonic vibration in these alloys as affected by increased frequency.

4326 DEVELOPMENT OF NONDESTRUCTIVE TESTING INSTRUMENTATION FOR REACTOR
PRESSURE VESSELS
W. J. McGonnagle
Southwest Research Inst., San Antonio, Texas, July 15, 1963

An investigation is being conducted to develop a nondestructive test-
ing technique for measuring the shift in the nil ductility transition
temperature of A-212 Grade B steel. A correlation was found between
the amount of cold working and magnetoabsorption, thermal conductivity,
and ultrasonic attenuation. Magnetoabsorption measurements as a
function of cold work in A-212 Grade B steel appear to be very
promising. The measurement of the ultrasonic attenuation coefficient
in cold work material by a through transmission technique showed a
relationship between cold work and the attenuation coefficient. The
thermal comparator shows applicability to measuring the level of
cold work in A-212 Grade B steel. It appears that all three of the
techniques evaluated have potential for determining the level of
cold work in A-212 Grade B steel.

4341 ULTRASONIC STUDY OF THE CUBIC-TETRAGONAL PHASE CHANGE AND THE CURIE
TEMPERATURE OF SINGLE CRYSTAL $SrTiO_3$
R. S. Krogstad and R. W. Moss
Boeing Scientific Research Labs., Seattle, March 1962, 12 p.

An investigation is described in which attenuation and sound velocity
as a function of temperature were measured over a frequency range
10 to 150 mc/sec on single crystal specimens of $SrTiO_3$ along three
principal crystallographic directions at room temperature to that of
liquid He. It was found that ultrasonic attenuation in $SrTiO_3$ ex-
hibits two dominant maxima; one starting at 110 degrees K which is
attributed to the scattering of phonons at the interfaces between
cubic and tetragonal domains which coexists in a narrow temperature
range below this point, and a second below about 48 degrees K which
is ascribed to ferroelectric dielectric losses.

4365 ULTRASONIC ATTENUATION IN SUPERCONDUCTING LEAD
R. E. Love and R. W. Shaw
Reviews of Modern Physics, Vol. 36, No. 1, Pt. 1, January 1964,
p. 260-263

Measurement of the ultrasonic attenuation of Pb in various crystal-
lographic directions over the $2°$ to $20°K$ temperature range both in
magnetic field and zero field to determine the superconducting energy
gap.

4436 ACUSTO-ELASTIC AND ACUSTO-PLASTIC DEFORMATIONS IN ROLLED Cr-Ni-Mo
STEEL PIPES
J. Pirs
Rudarsko-Metalurski Zbornik, No. 2, 1964, p. 137-156 (in Solvenian)

The plastic deformation phenomena in Cr-Ni-Mo steel pipes are in-
vestigated by ultrasonic methods. It is evident from results ob-
tained that stresses caused by deformation affect ultrasonic
attenuation and sound propagation within the pipe. Data can be used
to calculate the degree of deformation and stresses created by such
deformations.

4454 MEASUREMENT OF CHILL DEPTH ON CAST IRON TEST PIECES AND ROLLS
J. L. Smith and A. G. Fuller
BCIRA Journal, Vol. 12, No. 3, May 1964, p. 319-326

A technique for estimating chill depth in chilled test castings and
iron rolls by measuring the delay between introduction of ultrasonic
energy into the casting and the first echo occurring as a result of
attenuation of the signal in the mottled zone. Accuracy is greatest
when the transition from the chilled zone to the gray core is sharp.

DESCRIPTOR INDEX

All descriptors listed in alphabetical order pertain to the information contained in the report or item that is identified by the AMRA number following the descriptor. This journal is for Ultrasonic Attenuation literature and every item in the journal contains some aspect of the subject. A complete breakdown of the subject by descriptors was deemed necessary in order to make the journal more useful.

Reviewers need only to refer to the item numbers which apply to the particular descriptors of interest and turn to the abstract applicable to those referenced numbers.

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